DEPARTMENT OF THE ARMY
WILMINGTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1890
WILMINGTON. NORTH CAROLINA 28402-1890

REPLY TO
ATTENTION OF:

CESAW-TS-PS

29 November 2004

MEMORANDUM THRU CESAD-PDS-P/Paynes

FOR CECW-SAD/Fach

SUBJECT: Dare County Beaches, North Carolina (Bodie Island Portion), Response to Chief's Report

1. References:

a. Dare County Beaches (Bodie Island Portion), North Carolina Final Feasibility Report and EIS, September 2000.

b. Chief of Engineers Report, 20 December 2000, subject as above.

c. Headquarters Policy Compliance Review Comments, 20 August 2004, subject as above.

d. Modified Addendum, November 2004, subject as above.

2. In the Chief's Report for the Dare County Beaches, North Carolina (Bodie Island Portion) Project dated December 2000, three conditions were included which required actions to be taken by the Wilmington District during the preconstruction engineering and design (PED) phase of the project.

3. Actions were taken to address these conditions and documented in a letter report dated May 2003, an Addendum dated November 2003, and an Addendum Supplement dated June 2004. These documents were the subject of Headquarters Policy Compliance Review Comments transmitted 20 August 2004. A Strategic Planning Meeting was held on 23 September 2004 between representatives of Dare County, HQUSACE, CESAD, and the Wilmington District. Annotated minutes of that meeting are included as attachment 2 to the enclosed Addendum.

4. Enclosure 1 is a modified Addendum dated November 2004. The Addendum includes 5 enclosures in support of our findings. Enclosure 2 is the Comments and Responses dated 19 November 2004 in response to the 20 August 2004 comments from HQUSACE. We believe that this package, taken together with the previous Feasibility Report is fully responsive to the conditions in the Chief's Report and meets the guidance provided at the 23 September 2004 meeting.

5. We request concurrent review by HQUSACE and CESAD and agreement that the conditions of the Chief's Report have been met.

6. If we can be of further assistance, please contact Coleman Long, Chief, Planning and Environmental Branch, 910-251-4505.

2 Encls

BEN F. WOOD II, P.E.
Deputy District Engineer for
Programs and Project Mgmt

Addendum
November 2004

US Army Corps
of Engineers®

ADDENDUM TO THE
DARE COUNTY BEACHES, NORTH CAROLINA
(BODIE ISLAND PORTION)
FINAL FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

EXECUTIVE SUMMARY

This addendum was prepared to provide updated information on the Administration's position concerning Federal support of shore protection projects and to address concerns expressed in the Chief of Engineers report proposing construction of the Dare County Beaches project.

When the feasibility report was prepared and circulated in August 2000, it was the policy of the Administration not to support authorization of new shore protection projects that involve significant long-term Federal investment. That policy has been revised as reflected in EC 11-2-184 to support new starts for shore protection.

The Chief's concerns were identified as conditions that required resolution during pre-construction engineering and design (PED) and prior to implementation of the recommended project. The first condition was to confirm or support revision of the erosion damage relationships used in the project economic analysis as a basis for identifying the national economic development plan and the Federal interest and participation in the recommended project. The Wilmington District applied various erosion-damage curves to coastal structures depending on their elevation, piling length, and size of lower enclosure. Application of these curves represents expected damages that more closely simulate actual storm events. The new curves were first applied to the Bogue Banks Section 933 study to verify and then used to rerun the Dare County analysis. Results indicate a slight decrease in the total project benefits but all elements of the recommended project are still economically feasible and the authorized plan is still the NED plan. The District also performed a sensitivity analysis on the damage indicators used for the project and concludes that they are within a reasonable range.

The second condition was to ensure that public access to all segments of the 14.2-mile-long project is consistent with law and regulation prior to initial construction and each re-nourishment. Dare County is currently developing a plan for access and parking to satisfy our access requirement and are committed to providing the required accesses. The details and 100% non-federal costs for access will be documented in the Project Cooperation Agreement (PCA).

The third condition was to continue to coordinate with environmental resource agencies and environmental protection advocacy groups during the PED phase of the project to address their concerns and to conduct studies or other activities as necessary. The District has conducted 5 stakeholder meetings and several scoping sessions to further discuss resource concerns, coastal engineering models, and economic analysis. An agreement was reached with environmental resource agencies to develop a comprehensive monitoring plan that would include pre and post project monitoring to help develop a better data base for impacts to benthic resources in the borrow area, impacts to near shore fisheries, and impacts to shorebirds. This monitoring plan was completed in February 2004 and monitoring began in May 2004.

INTRODUCTION AND BACKGROUND

This study was conducted pursuant to a congressional resolution pertaining to Dare County beaches. The primary study emphasis was directed toward shore protection measures at Nags Head, Kill Devil Hills, and Kitty Hawk. The text of the authorizing resolution, adopted 1 August 1990 by the United States House of Representatives, is:

> “Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Secretary of the Army, in accordance with section 110 of the River and Harbor Act of 1962, is requested to make, under the direction of the Chief of Engineers, studies of the Dare County beaches, Dare County, North Carolina, in the interest of beach erosion control, hurricane protection, storm damage reduction needs, and related purposes.”

Based on the authority contained in the above congressional resolution, the scope of the study was limited to developing solutions to problems associated with ocean shoreline erosion and damage caused by ocean storms and their related impacts. The study did not address problems that may result from storms acting over the sounds west of the barrier island.

Investigations for hurricane protection and beach erosion control needs were conducted along a portion of Dare County beaches to develop the optimum plan of protection for this area. Dare County beaches are located on the northeastern North Carolina Coast. The beachfront in Dare County that the local sponsor requested to be investigated for shore protection needs includes the resort communities of Nags Head, Kill Devil Hills, and Kitty Hawk. A significant portion of this 20-mile-long shoreline reach is rapidly eroding. Numerous structures in this area have been damaged by storm action. Also, with an eroded dune system, this area is highly vulnerable to future storm action. Based on analyses conducted during the study, it was determined that the most practicable improvement for shore protection is a berm and dune project (with transitions) along the southern 10.1 miles of Nags Head and along 4.1 miles of Kill Devil Hills and Kitty Hawk. These are the only two reaches of the 20-mile-long shoreline of Nags Head, Kill Devil Hills and Kitty Hawk where Federal improvements were determined to be economically justified.

The Feasibility Report and Environmental Impact Statement was published in August 2000, under the title “Final Feasibility Report and Environmental Impact Statement for Hurricane Protection and Beach Erosion Control, Dare County Beaches (Bodie Island Portion), Dare County, North Carolina.” The Feasibility Report underwent a detailed review within the Corps and a 30-day State and Agency Review. Numerous concerns were raised and resolved during these reviews and the project recommendation was altered to reflect these reviews.

The Report of the Chief of Engineers was published on December 2000 and included the following conditional approval:

> "Therefore, I recommend implementation of the project subject to the following conditions and with such modification as in the discretion of the Chief of Engineers may be advisable. During the preconstruction engineering and design (PED) phase, the district will undertake studies to confirm or support revision of the damage relationships used in the project economic analysis as a basis for identifying the national economic development plan and the Federal interest and participation in the recommended project. The district engineer will ensure that public access to all segments of the 14.2-mile-long project is consistent with law and regulation prior to initial construction and beach nourishment. Finally, the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, and the National Marine Fisheries Service expressed concerns regarding the adequacy of the analysis of cumulative impacts; suitability of sand for beach nourishment; turbidity impacts on important fisheries; and impacts of sediment transport to Oregon Inlet. Several environmental protection advocacy organizations communicated similar concerns. The reporting officers will continue to coordinate with environmental resource agencies and environmental protection advocacy groups during the PED phase of the project to address their concerns and will conduct studies of other activities as necessary."

This Addendum presents a summary of the efforts to address the conditions and the associated findings. The project was funded for construction in the fiscal year 2003 Omnibus Bill.

PURPOSE OF THE ADDENDUM

This Addendum is intended as an extension of the feasibility report to address conditions in the Chief's Report. Detailed technical information used in the feasibility study, which is not needed for this Addendum, is not reiterated here. The August 2000 Feasibility Report, to which this addendum is attached, should be reviewed for a detailed description of the project area, problems, needs, and opportunities, the selected plan and all technical analyses that were used in developing the selected plan.

During the feasibility study review process, numerous issues were raised, discussed and resolved. This addendum addresses Administration policy on shore protection projects and the three issues identified in the Chief's Report, which are:

- Confirm or support revision of the erosion damage relationships used in the project economic analysis as a basis for identifying the national economic development plan and the Federal interest and participation in the recommended project.
- Ensure that public access to all segments of the 14.2-mile-long project is consistent with law and regulation prior to initial construction and each nourishment.

- Continue to coordinate with environmental resource agencies and environmental protection advocacy groups during the PED phase of the project to address their concerns and to conduct studies or other activities as necessary.

ADMINISTRATION POLICY

The feasibility report included the following statement in the Syllabus:

> It should be noted that the Administration's position on funding support for hurricane and storm damage reduction projects is as follows: "The Office of Management and Budget advises that while the Water Resources Development Act of 1999 (WRDA 99) changed the cost-sharing formula for the long-term sand renourishment component of certain future shore protection projects, these changes did not go far enough considering the long-term cost of most of these projects. Further, because WRDA 99 delayed the effect of the change in cost sharing for up to a decade or more, it did not address current constraints on Federal spending. The Administration intends to work with Congress to address these problems. However, until these issues are satisfactorily resolved, the Administration will not support authorization of new shore protection projects that involve significant long-term Federal investments beyond the initial construction of these projects, and will give new shore protection projects that are already authorized low priority for funding."

The current Administration policy is contained in EC 11-2-184, Corps of Engineers Civil Works Direct Program, Program Development Guidance, dated 31 March 2003 and contains the following language:

> "Eligible new starts include all active authorized feasibility studies which have not received an initial work allowance. The needs to be addressed should be of broad national scope and significance and should include at least one of the following: commercial navigation; inland navigation; flood damage reduction; hurricane and storm damage reduction;...."

EROSION DAMAGE RELATIONSHIPS

The purpose of this study is to investigate the effects of varying assumptions on the selected plan for the Dare County Beaches project, authorized in the Water Resources Development Act (WRDA) of 2000. Section 101(b)(24) of WRDA 2000 authorized construction of a project for hurricane and storm damage reduction for Dare County beaches, North Carolina, subject to the completion of a favorable report of the Chief of Engineers and subject to the conditions recommended in that final report. The report recommended implementation of the project subject to certain conditions and with such modification as in the discretion of the Chief of Engineers may be advisable. During preconstruction engineering and design (PED) phase, the district has undertaken studies to confirm or support revision of the erosion damage relationships used in the project economic analysis as a basis for identifying the national economic development plan and the Federal interest and participation in the recommended project. This sensitivity analysis of the Dare County Beaches Report will address this condition and provide information to fulfill the conditions of the Feasibility report. The three specific points that are addressed are consistency with North Carolina CAMA regulations, erosion damage curves, and vertical erosion indicators.

North Carolina CAMA Regulations

The District revisited North Carolina's policies concerning replacing structures lost in storm events and concluded that the assumptions used in the feasibility report are still valid. North Carolina CAMA regulations preclude replacement of a structure only after the lot is deemed unbuildable when set back restrictions dictate that a structure cannot be put back on the lot. 15A NCAC 07H .2501 allows for a great deal of latitude for meeting rebuilding criteria following damages due to hurricanes or tropical storms. Issuing emergency permits for rebuilding on lots meeting a minimal setback restriction is generally the rule not the exception in North Carolina. Based on common practice and historical evidence, our model allows for rebuilding structures lost in storms provided setback restrictions are met. Only after long-term erosion has claimed more distance on the oceanfront lot than the building requires to be put back, does our program cease to reinstate the same property. The District reviewed the replacement assumptions in the feasibility report and determined that they are still valid. In fact, they appear to be conservative since typically each destroyed structure is rapidly replaced with a more valuable building than the one lost.

Refinement of Erosion-Damage Relationship

General Methodology. The recommended plan was recomputed using the same project design and extent as in the original Feasibility Report. The same level of development, interest rate, construction time, and other variables were used in this analysis. The only changes were in the erosion-damage relationships. To analyze the effect of using erosion-damage curves other than the ones used in the Feasibility Study, all the structures in the oceanfront and next row back within the National Economic Development (NED) Plan limits were rerun through the Generalized Risk and Uncertainty Coastal (GRANDUC) model. The original study area was not reevaluated since the new erosion-damage curves yield less damage than those used in the Feasibility Study and, therefore, could not result in any formerly eliminated segments of development now being included in the NED Plan.

Originally, three categories of benefits were analyzed for the initial evaluation of the structural plans over the 20-mile study area. These benefit categories include: (1) hurricane and storm damage reduction, including land loss; (2) emergency costs and other damage reduction; and (3) recreation. Only expected storm and erosion related damages are affected by altering the erosion-damage curves, and are therefore recomputed based on the new curves. The expected annual benefits for emergency cost reduction and recreation remain unchanged from the Feasibility Study. Benefits during construction, which are primarily comprised of hurricane and storm damage reduction benefits, are kept at the same proportion of the total benefits as in the Feasibility Study.

Revised Estimates. This revision of estimates of potential damages was based on changing one of the critical, underlying relationships that go into the damage calculations, namely, the erosion-damage curves. The historical effects of long-term and storm related erosion on oceanfront structures along the beaches of North Carolina are not well documented. Very little data exists on how these structures react to storm forces of varying degrees of intensity. This lack of data has lead to the designing of erosion-damage curves comprised largely through professional judgment. The state of the art of modeling these relationships is improving, however, following the hurricanes of 1996-1999 along the North Carolina coast. Researchers like Spencer Rogers of North Carolina Sea Grant have begun collecting and analyzing data and publishing papers on this subject. In his report, “Erosion Damage Thresholds in North Carolina,” Mr. Rogers derived storm induced damage curves based on observed changes over time in coastal construction in North Carolina. The curves used in this analysis are derived from these erosion-damage curves and are based on field data including the following structure identities:

- Oceanfront or not
- Number of stories
- On piles or not, long or short piles
- Size of the under house enclosure (none, small, partial, fully enclosed)
- Type of enclosure (none, finished, unfinished)
- High or low existing dune (potential to undermine)
- Structure type (commercial or residential)

For this analysis, these data were collected for every structure along the oceanfront and first row of development back from the oceanfront, along with their elevation and depreciated replacement value. The following further describes the four-character coding scheme of structure types used for this study, which was originally developed by a North Carolina State University team of researchers including Mr. Rogers. These codes are assigned upon field inspection of each structure and matched with both an appropriate erosion-damage curve and an inundation-damage curve. The analysis presented below was reviewed by Mr. Rogers and his assessment is included as attachment 1.

Building Inventories

Four character scheme used for Bogue Banks database:

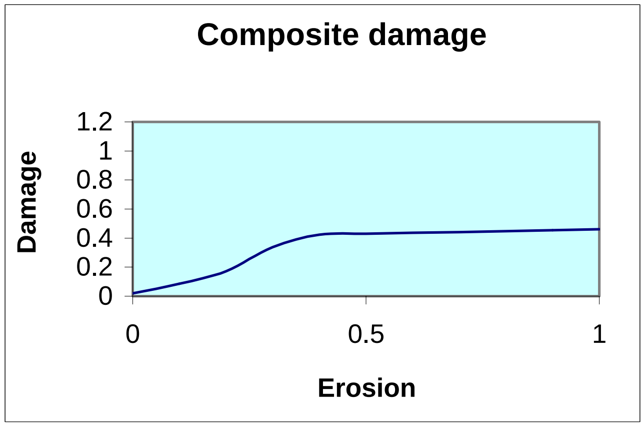
1. Number of stories (1,2,3)
2. On piles or not (P or N)
3. Size of underhouse enclosure (N=none, S=small (300 ft^2 or less), P=partial (300 ft^2 to full), F=fully enclosed)
4. Type of enclosure (N=none, F=finished, U=unfinished)

Yielding the following list of structure types:

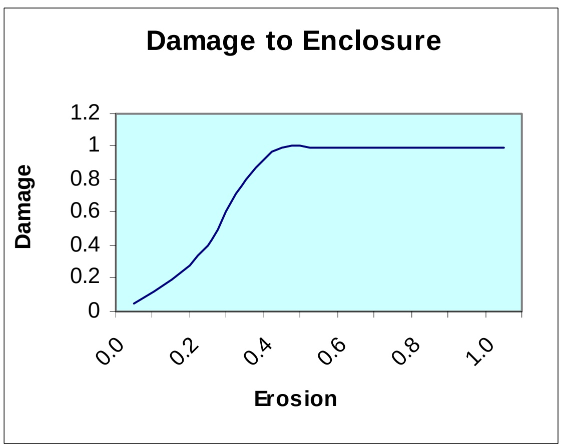
Type	Description
1NNN	One story on grade or low/crawl space foundation
1PNN	One story elevated on piles, no enclosures below
1PSF	One story elevated on piles, enclosed finished area below (enclosure less than or equal to 300 $ft^{2)}$
1PPF	One story elevated on piles, enclosed finished area below (enclosure greater than 300 ft^2 but less than full)
1PFF	One story elevated on piles, enclosed finished area below (full enclosure)
1PSU	One story elevated on piles, unfinished enclosure below (enclosure less than 300 ft^2)
1PPU	One story elevated on piles, unfinished enclosure below (enclosure greater than 300 ft^2 but less than full)
1PFU	One story elevated on piles, unfinished enclosure below (full enclosure)
2NNN	Two story on grade or low/crawl space foundation
2PNN	Two story elevated on piles, no enclosures below
2PSF	Two story elevated on piles, enclosed finished area below (enclosure less than 300 ft^2)
2PPF	Two story elevated on piles, enclosed finished area below (enclosure greater than 300 ft^2 but less than full)
2PFF	Two story elevated on piles, enclosed finished area below (full enclosure)
2PSU	Two story elevated on piles, unfinished enclosure below (enclosure less than 300 $ft^{2)}$
2PPU	Two story elevated on piles, unfinished enclosure below (enclosure greater than 300 ft^2 but less than full)
2PFU	Two story elevated on piles, unfinished enclosure below (full enclosure)

The erosion-damage curves used for this analysis are compilations of curves assigned for each part of the structure. For example, the curve 1 below is a compilation of curves 2 and 3 with weight given in proportion to the value assigned to each part of the structure. This example is for a 1PF, which is a 1-story house on pilings with a full enclosure. It is further described as having long pilings and on low elevation. The enclosure is given a value of 40% of the entire structure and the rest of the structure is given a value of 60% of the entire structure value. These percentages were then used to weight the damage curves for the home and the enclosure and derive a composite damage curve.

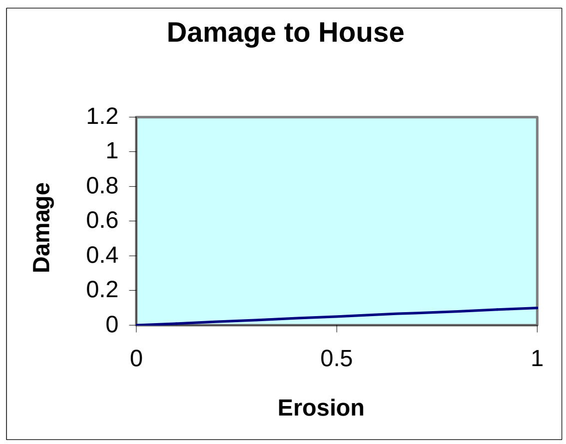
Curve 1



Curve 2



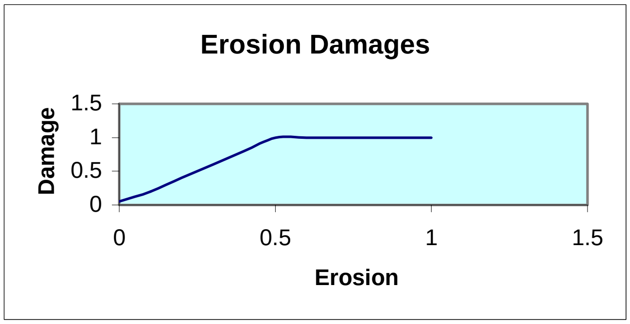
Curve 3



Estimated construction dates were used during the data collection to assist in determining whether or not a structure was on long or short pilings. The North Carolina coastal construction codes changed in 1986 to require longer pilings than the 8 feet below grade to either -5 feet NGVD or 16 feet below grade, whichever is shallower. We developed our damage curves to distinguish between structures with long or short pilings because the storm damages are different for the two piling lengths. The curves were different for high and low dune elevation as well. For dunes up to 12 feet, the piles would extend far enough below the scarp to support the structure. For structures on dunes greater than 12 feet, scarping would cause the foundation to fail and the building to collapse.

Another consideration for curve assignment is whether the structure is in the oceanfront row or the second row. Those residential oceanfront structures with enclosures were typically assigned some variation of curves 1 or 2 above, depending on their age, length of piling, and size and quality of enclosure. Oceanfront homes with no enclosure, on a low dune, and pilings embedded 16 feet were assigned curve 3, which produces relatively minor damages. Oceanfront structures are most vulnerable to erosive forces and are typically built to the higher building code standard. Residential structures along the second row of development were also assigned an erosion-damage curve specific to their building characteristics, which often include shorter pilings. In this case, the structures were often assigned a more aggressive erosion-damage curve like curve 4 shown below.

Curve 4



The erosion indicator, or erosion depth threshold, is a vertical measurement that is used to look at erosion through structures. As the land erodes by this vertical amount though a structure, damage accrues to the structure. An erosion indicator of 0.5 feet was used for this analysis. Sensitivity analyses were done to examine the effects of changes in content value percentages, erosion indicators, and assignment of erosion curves from the simplest to curves that are composites of damages to different parts of the structure.

Recommended (NED) Plan. Net benefits per reach were used to determine the length of feasible project reaches, since it is evident that providing a project on some of the beach segments is not economically feasible. Determining the length of projects is accomplished by focusing on continuous segments of beach with positive net benefits. Segments of beach with positive net benefits were combined to formulate two distinct project reaches, a North Project Area and a South Project Area, each with transitional zones to the north and south and a distance of about three miles between them. The primary factor in determining whether a project is justified over a given segment of beach is the density of the development. Wherever relatively inexpensive, single unit housing dominates a segment, the potential for storm damage reduction within that segment may not be great enough to cover the expected costs. Other contributing factors are the erosion rate, wave energy, existing protective dunes, and distance from the borrow source. Overall project constructability is another important consideration. The project should have a constructible and maintainable geometry, which encompasses the longest length of shoreline for which there are positive net benefits. Sections of contiguous shoreline, which have negative net benefits and sufficient length to stop and start a project, are not included. Sections of shoreline at the ends of projects that have negative net benefits are not included in the plan of improvement. The remains, i.e., those sections of contiguous shoreline segments that are economically feasible, become the boundaries for the plan of improvement. Once these project boundaries are established, the alternative beach fill configurations are run again with transitions and refined cost data to more accurately reflect the net benefits associated with each plan.

The alternative that maximizes net benefits in nearly every segment of beach is the plan that combines a 50-foot wide berm with a dune at 13 feet NGVD, hereafter referred to as the 13/50 dune and berm. Using new erosion-damage curves, the 13/50 dune and berm are still found to be the NED Plan. Because the new erosion curves did not change the recommended plan significantly, two additional berm and dune plans, the 13/25 and 13/100, were not re-evaluated and do not show potential to be the NED plan. The present value of the net benefits for the North and South Project Areas for the remaining eight alternatives are shown in table H-5 in the feasibility report. Again, the 13/50 plan out performed all other plans based on yielding the highest net benefits over both project segments and is designated as the NED Plan. This is further demonstrated with the volumetric plots of the two projects in figures 5 and 6 in the feasibility report.

Transition Zone Benefits. Benefits along the 3,000-foot long transition zones are computed within the GRANDUC framework just like any other segment of beach. However, the further from the main project fill, the less protection that segment of beach receives. In other words, the beach fill alternative being evaluated is tapered from full project dimensions where the transition zone begins all the way down to the existing shoreline at the end of the transition. Transition zone benefits are included in the project benefit totals and consist of all three benefit categories—hurricane and storm damage reduction, emergency costs and other damage reduction, and recreation.

Effects on the Hurricane & Storm Damage Reduction Benefits of the NED Plan Economics from Changing Erosion-Damage Curves. The table below compares the expected annual benefits and costs and re-computes the benefit-to-cost data for the13/50 dune and berm plan, i.e., NED Plan. As shown in the table from the Feasibility Study, the benefit-to-cost ratio for the North Project Area, South Project Area, and total project, based soley on hurricane and storm damage reduction, are all favorable at 1.3, 2.4, and 1.9, respectively.

With the changes in the erosion-damage curves in this reanalysis, those same benefit-to-cost relationships are 1.3, 1.9 and 1.7, respectively.

NORTH PROJECT

Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
$115,585,402	$98,604,199	$16,981,203	$114,947,910	$98,604,199	$16,343,708

SOUTH PROJECT

Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
$342,927,515	$141,645,449	$201,282,061	$273,368,751	$141,645,449	$131,723,308

The age of the development in the North Project Area is generally older than that of the South Project area. In addition, the South Project area has generally made a much larger effort to save the homes by sandbagging and extending piling lengths. These are the reasons benefits decreased more in the South Project area than the North Project area with the application of the new erosion-damage curves. Basically, the curve assignments in this reanalysis for the North Project area required relatively few changes since structures are typically older, constructed with 8-foot embedded pilings, and highly susceptible to erosion damage. Upon reevaluation of the oceanfront and second row development in January 2003, only 95 structures or 6 percent of the structures were changed to the new, less aggressive erosion damage curves. Recent history shows that these North Project area structures are failing and being destroyed as they are threatened by erosion.

Conversely, a significant number of structures in the South Project area were found to be more damage resistant and justify the use of the new, less aggressive erosion-damage curves. The January 2003 reanalysis led to changing the erosion-damage relationship on 410 structures or 19 percent of the total structures. Again, this is ground-truthed by the fact that fewer structures have been lost in recent years in the South Project area.

Effects on the Total Benefits of the NED Plan Economics from Changing Erosion-Damage Curves. Of the three categories of benefits that were analyzed for the initial evaluation of the structural plans in the Feasibility Study, namely, (1) hurricane and storm damage reduction, including land loss; (2) emergency costs and other damage reduction; and (3) recreation, only expected storm and erosion related damages are affected by altering the erosion-damage curves. Therefore, this is the only benefit category that has been recomputed based on the new curves. The expected annual benefits for emergency cost reduction and recreation remain unchanged from the Feasibility Study. Benefits during construction, which are primarily comprised of hurricane and storm damage reduction benefits, are kept at the same proportion of the total benefits as in the Feasibility Study.

Summary of Benefits for the NED Plan. The expected annual benefits by category and North and South Project Areas are summarized in table 1. Benefits and costs for each reach (thousand foot segment) are also shown below. This reach-by-reach analysis includes hurricane and storm damage reduction and not the other benefit categories. Recreation benefits, emergency cost reductions, and benefits expected during construction are addressed in other sections of the report.

TABLE 1. Summary of Expected Annual Benefits—NED Plan

Benefit Category	North Project	South Project	Total
H&S Damage Reduction	$5,997,100	$16,932,600	$22,929,700
Emergency Costs Reduction	$139,600	$361,400	$501,000
Recreation	$1,843,700	$1,944,000	$3,787,700
Benefits During Construction	$1,329,200	$1,932,100	$3,261,300
Total	$9,309,600	$21,170,100	$30,479,700

North Project				
Reach	Net Ben Change	# of Struc	Total Struc Value	Most Freq Curve
210	-$262,138	10	$707,175	1 to 38
214	-$93,658	8	$661,825	1 to 38 1 to 41

South Project				
Reach	Net Ben Change	# of Struc	Total Struc Value	Most Freq Curve
350	-$11,665,336	6	$7,893,750	1 to 39
357	-$10199144	6	$10,800,000	1 to 39 10 to 42

North Project Reach	Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
123	$3,716,218	$5,475,035	-$1,758,816	$3,716,218	$5,475,035	-$1,758,816
124	$631,570	$1,588,467	-$956,896	$631,570	$1,588,467	-$956,896
125	$1,889,493	$2,790,809	-$901,316	$1,889,493	$2,790,809	-$901,316
126	$1,010,044	$1,557,768	-$547,724	$1,010,044	$1,557,768	-$547,724
127	$2,565,386	$3,434,904	-$869,517	$2,565,386	$3,434,904	-$869,517
128	$15,109,822	$5,322,616	$9,787,201	$15,166,952	$5,322,616	$9,844,338
129	$3,212,196	$2,595,736	$616,461	$3,220,568	$2,595,736	$624,830
130	$1,433,250	$806,542	$626,708	$1,424,930	$806,542	$618,388
131	$3,266,895	$4,119,609	-$852,712	$3,289,088	$4,119,609	-$830,520
132	$855,728	$784,877	$70,851	$853,285	$784,877	$68,409
133	$1,066,790	$2,065,578	-$998,789	$1,065,913	$2,065,578	-$999,665
134	$1,532,022	$1,709,672	-$177,651	$1,464,650	$1,709,672	-$245,021

North Project Reach	Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
135	$1,802,692	$1,628,226	$174,466	$1,752,600	$1,628,226	$124,373
201	$1,172,165	$1,462,955	-$290,790	$1,135,458	$1,462,955	-$327,498
202	$2,189,962	$2,805,730	-$615,768	$2,207,015	$2,805,730	-$598,716
203	$2,160,321	$2,196,200	-$35,880	$2,165,154	$2,196,200	-$31,046
204	$2,729,307	$2,928,498	-$199,192	$2,746,262	$2,928,498	-$182,238
205	$2,923,870	$3,055,138	-$131,267	$2,950,605	$3,055,138	-$104,533
206	$2,029,557	$2,331,321	-$301,764	$2,000,672	$2,331,321	-$330,649
207	$1,903,768	$1,739,814	$163,954	$1,872,672	$1,739,814	$132,858
208	$3,126,297	$3,718,504	-$592,207	$3,160,324	$3,718,504	-$558,178
209	$5,936,411	$3,381,737	$2,554,676	$5,934,142	$3,381,737	$2,552,402
210	$3,962,765	$2,742,013	$1,220,750	$3,700,624	$2,742,013	$958,612
211	$4,827,132	$3,275,188	$1,551,944	$4,795,352	$3,275,188	$1,520,167
212	$1,413,595	$1,526,328	-$112,734	$1,383,510	$1,526,328	-$142,819
213	$2,628,752	$2,317,763	$310,991	$2,572,680	$2,317,763	$254,917
214	$2,503,782	$2,109,238	$394,545	$2,410,124	$2,109,238	$300,887
215	$2,220,636	$2,260,698	-$40,061	$2,178,964	$2,260,698	-$81,734
216	$1,679,425	$2,100,355	-$420,930	$1,626,404	$2,100,355	-$473,952
217	$5,607,760	$2,561,656	$3,046,103	$5,578,846	$2,561,656	$3,017,188

North Project Reach	Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
218	$11,641,827	$2,868,628	$8,773,205	$11,640,766	$2,868,628	$8,772,140
219	$3,228,154	$2,717,940	$510,214	$3,229,829	$2,717,940	$511,889
220	$3,788,863	$1,451,012	$2,337,849	$3,788,863	$1,451,012	$2,337,849
221	$4,208,351	$1,637,560	$2,570,790	$4,208,351	$1,637,560	$2,570,790
222	$1,532,154	$2,654,104	-$1,121,951	$1,532,154	$2,654,104	-$1,121,951
223	$717,685	$1,665,874	-$948,189	$717,685	$1,665,874	-$948,189
224	$438,620	$1,210,078	-$771,457	$438,620	$1,210,078	-$771,457
225	$1,093,862	$2,985,663	-$1,891,802	$1,093,862	$2,985,663	-$1,891,802
226	$842,239	$2,257,355	-$1,415,116	$842,239	$2,257,355	-$1,415,116
227	$986,036	$2,763,010	-$1,776,976	$986,036	$2,763,010	-$1,776,976
Totals	**Benefits**	**Costs**	**Net Benefits**	**Benefits**	**Costs**	**Net Benefits**
	$115,585,402	$98,604,199	$16,981,203	$114,947,910	$98,604,199	$16,343,708

South Project Reach	Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
314	$1,113,669	$741,664	$372,006	$1,113,669	$741,664	$372,006
315	$803,208	$655,360	$147,847	$803,208	$655,360	$147,847
316	$803,467	$1,094,831	-$291,364	$803,467	$1,094,831	-$291,364
317	$818,456	$1,134,708	-$316,251	$818,456	$1,134,708	-$316,251

South Project Reach	Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
318	$1,253,270	$849,914	$403,356	$1,253,270	$849,914	$403,356
319	$648,490	$682,388	-$33,898	$648,490	$682,388	-$33,898
320	$526,649	$829,967	-$303,318	$526,649	$829,967	-$303,318
321	$837,027	$1,222,499	-$385,472	$837,027	$1,222,499	-$385,472
322	$4,621,057	$1,298,997	$3,322,060	$4,622,769	$1,298,997	$3,323,772
323	$2,217,960	$604,677	$1,613,283	$2,287,438	$604,677	$1,682,763
324	$526,980	$806,254	-$279,273	$526,661	$806,254	-$279,593
325	$1,740,060	$964,289	$775,771	$1,739,723	$964,289	$775,434
326	$1,330,938	$725,488	$605,451	$1,331,607	$725,488	$606,120
327	$852,568	$971,232	-$118,663	$852,540	$971,232	-$118,692
328	$954,822	$717,224	$237,597	$954,812	$717,224	$237,587
329	$4,009,618	$1,878,098	$2,131,522	$3,467,570	$1,878,098	$1,589,471
330	$5,535,030	$1,584,075	$3,950,956	$2,356,288	$1,584,075	$772,214
331	$772,297	$922,210	-$149,913	$772,007	$922,210	-$150,202
332	$3,613,653	$1,862,470	$1,751,184	$1,592,306	$1,862,470	-$270,163
333	$2,849,762	$1,771,914	$1,077,847	$2,240,700	$1,771,914	$468,785
334	$1,319,426	$775,688	$543,738	$1,153,274	$775,688	$377,586
335	$1,534,281	$1,160,167	$374,113	$1,038,225	$1,160,167	-$121,943

South Project Reach	Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
336	$1,808,268	$1,595,875	$212,393	$1,165,004	$1,595,875	-$430,870
337	$1,438,873	$1,650,016	-$211,144	$928,230	$1,650,016	-$721,785
338	$677,004	$732,802	-$55,798	$565,145	$732,802	-$167,657
339	$1,539,706	$1,080,838	$458,868	$640,648	$1,080,838	-$440,190
340	$1,695,823	$1,149,101	$546,722	$906,970	$1,149,101	-$242,131
341	$1,191,368	$1,242,037	-$50,670	$633,750	$1,242,037	-$608,288
342	$1,947,703	$1,128,876	$818,827	$1,616,652	$1,128,876	$487,776
343	$6,555,342	$1,828,560	$4,726,778	$3,523,929	$1,828,560	$1,695,369
344	$1,433,415	$1,336,475	$96,940	$1,198,848	$1,336,475	-$137,628
345	$1,175,112	$771,476	$403,636	$833,642	$771,476	$62,166
346	$1,914,279	$1,501,391	$412,887	$7,841,326	$1,501,391	$6,339,932
347	$1,682,812	$885,889	$796,922	$1,127,564	$885,889	$241,675
348	$1,065,888	$693,681	$372,207	$1,008,148	$693,681	$314,468
349	$3,506,296	$1,140,720	$2,365,576	$3,426,536	$1,140,720	$2,285,815
350	$16,648,404	$1,826,086	$14,822,316	$4,983,067	$1,826,086	$3,156,980
351	$2,109,814	$1,117,194	$992,619	$989,456	$1,117,194	-$127,739
352	$4,731,823	$1,350,178	$3,381,646	$2,447,497	$1,350,178	$1,097,319
353	$3,152,252	$759,334	$2,392,918	$1,341,797	$759,334	$582,464

South Project Reach	Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
354	$6,316,275	$1,173,858	$5,142,412	$6,318,012	$1,173,858	$5,144,158
355	$5,072,554	$936,042	$4,136,512	$2,135,647	$936,042	$1,199,604
356	$7,267,124	$1,098,018	$6,169,105	$3,260,838	$1,098,018	$2,162,818
357	$13,098,785	$1,181,827	$11,916,958	$2,899,641	$1,181,827	$1,717,814
358	$6,901,696	$1,361,672	$5,540,022	$2,408,074	$1,361,672	$1,046,402
359	$2,297,328	$1,264,042	$1,033,286	$1,037,622	$1,264,042	-$226,419
360	$3,652,234	$1,405,347	$2,246,887	$1,793,494	$1,405,347	$388,146
361	$7,493,842	$1,361,272	$6,132,569	$3,634,116	$1,361,272	$2,272,844
362	$2,101,299	$620,102	$1,481,197	$2,098,511	$620,102	$1,478,409
363	$1,357,840	$855,326	$502,515	$1,359,953	$855,326	$504,627
364	$927,410	$1,388,189	-$460,779	$926,912	$1,388,189	-$461,277
365	$1,267,866	$1,097,744	$170,121	$1,269,798	$1,097,744	$172,053
366	$771,640	$926,222	-$154,582	$771,846	$926,222	-$154,376
367	$997,957	$960,526	$37,431	$994,388	$960,526	$33,862
368	$738,296	$825,595	-$87,300	$738,202	$825,595	-$87,393
369	$1,572,719	$1,230,388	$342,331	$1,572,774	$1,230,388	$342,385
370	$1,217,341	$1,440,789	-$223,448	$1,221,758	$1,440,789	-$219,031
371	$1,261,892	$789,004	$472,889	$1,280,601	$789,004	$491,597

South Project Reach	Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
372	$515,937	$731,830	-$215,892	$515,305	$731,830	-$216,525
373	$4,471,486	$1,422,801	$3,048,688	$4,482,748	$1,422,801	$3,059,946
374	$4,721,764	$1,008,861	$3,712,902	$4,723,190	$1,008,861	$3,714,330
375	$3,290,177	$628,777	$2,661,400	$3,288,779	$628,777	$2,660,001
376	$3,189,912	$1,110,739	$2,079,173	$3,189,563	$1,110,739	$2,078,824
377	$1,137,214	$995,512	$141,701	$1,135,942	$995,512	$140,431
378	$970,961	$1,490,446	-$519,485	$964,587	$1,490,446	-$525,857
401	$4,876,212	$1,716,099	$3,160,112	$3,372,572	$1,716,099	$1,656,473
402	$9,125,667	$1,442,688	$7,682,974	$9,196,025	$1,442,688	$7,753,341
403	$14,982,866	$1,714,855	$13,268,011	$14,541,584	$1,714,855	$12,826,729
404	$2,513,639	$1,135,217	$1,378,423	$1,637,695	$1,135,217	$502,479
405	$7,703,644	$1,209,832	$6,493,809	$3,702,784	$1,209,832	$2,492,952
406	$1,692,562	$1,169,545	$523,017	$1,647,531	$1,169,545	$477,986
407	$2,350,825	$1,262,746	$1,088,080	$1,685,226	$1,262,746	$422,479
408	$5,672,772	$1,172,070	$4,500,702	$2,581,052	$1,172,070	$1,408,983
409	$4,378,946	$1,022,390	$3,356,561	$4,217,850	$1,022,390	$3,195,462
410	$3,084,072	$1,448,030	$1,636,043	$2,863,133	$1,448,030	$1,415,102
411	$4,356,542	$2,175,096	$2,181,446	$4,257,964	$2,175,096	$2,082,868

South Project Reach	Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
412	$1,709,949	$1,030,706	$679,243	$1,655,666	$1,030,706	$624,959
413	$1,920,261	$1,293,954	$626,307	$1,904,970	$1,293,954	$611,015
414	$3,894,002	$1,670,743	$2,223,258	$3,872,252	$1,670,743	$2,201,510
415	$7,399,364	$1,126,530	$6,272,836	$7,186,310	$1,126,530	$6,059,776
416	$4,309,725	$1,689,862	$2,619,863	$4,375,166	$1,689,862	$2,685,304
417	$1,224,087	$652,717	$571,371	$1,182,448	$652,717	$529,731
418	$3,943,204	$2,047,020	$1,896,187	$3,908,086	$2,047,020	$1,861,066
419	$4,225,446	$1,595,551	$2,629,893	$3,964,227	$1,595,551	$2,368,674
420	$1,372,152	$780,336	$591,816	$1,340,777	$780,336	$560,440
421	$2,245,846	$907,517	$1,338,329	$2,185,992	$907,517	$1,278,474
422	$1,096,602	$648,143	$448,460	$1,100,829	$648,143	$452,686
423	$2,903,263	$1,568,930	$1,334,335	$2,486,072	$1,568,930	$917,143
424	$3,294,300	$2,063,912	$1,230,387	$2,997,694	$2,063,912	$933,783
425	$3,155,420	$1,669,622	$1,485,799	$2,843,156	$1,669,622	$1,173,534
426	$3,301,291	$1,503,837	$1,797,456	$3,298,857	$1,503,837	$1,795,022
427	$881,969	$724,091	$157,879	$882,916	$724,091	$158,825
428	$1,896,896	$1,226,927	$669,968	$1,916,077	$1,226,927	$689,150
429	$2,344,796	$1,531,154	$813,643	$2,244,362	$1,531,154	$713,208

South Project Reach	Feasibility Report Benefits	Feasibility Report Costs	Feasibility Report Net Benefits	New Erosion Curves Benefits	Feasibility Report Costs	New Erosion Curves Net Benefits
430	$5,002,104	$2,093,336	$2,908,767	$4,234,470	$2,093,336	$2,141,137
431	$2,511,082	$998,924	$1,512,156	$2,201,428	$998,924	$1,202,505
432	$2,910,224	$849,391	$2,060,833	$1,998,400	$849,391	$1,149,008
433	$3,046,479	$1,316,275	$1,730,203	$3,034,417	$1,316,275	$1,718,141
434	$3,076,213	$1,472,844	$1,603,368	$2,994,394	$1,472,844	$1,521,550
435	$1,852,573	$1,265,704	$586,868	$1,848,976	$1,265,704	$583,272
436	$2,365,930	$1,284,548	$1,081,383	$2,409,730	$1,284,548	$1,125,183
437	$4,035,329	$2,371,174	$1,664,156	$4,025,119	$2,371,174	$1,653,947
438	$2,582,771	$1,238,224	$1,344,547	$2,565,738	$1,238,224	$1,327,514
439	$1,210,354	$1,355,490	-$145,136	$1,220,883	$1,355,490	-$134,607
440	$2,572,738	$1,405,769	$1,166,970	$2,542,458	$1,405,769	$1,136,688
441	$2,568,928	$1,240,172	$1,328,756	$2,547,910	$1,240,172	$1,307,738
442	$4,315,966	$2,029,531	$2,286,436	$4,302,804	$2,029,531	$2,273,273
443	$4,013,551	$2,042,688	$1,970,862	$4,013,551	$2,042,688	$1,970,862
444	$1,461,657	$835,360	$626,297	$1,461,657	$835,360	$626,297
445	$2,335,310	$1,261,262	$1,074,049	$2,335,310	$1,261,262	$1,074,049
446	$1,787,669	$1,311,488	$476,181	$1,787,669	$1,311,488	$476,181
447	$1,556,728	$1,068,101	$488,626	$1,556,728	$1,068,101	$488,626

South Project	Feasibility Report	Feasibility Report	Feasibility Report	New Erosion Curves	Feasibility Report	New Erosion Curves
Reach	**Benefits**	**Costs**	**Net Benefits**	**Benefits**	**Costs**	**Net Benefits**
448	$2,792,974	$2,123,884	$669,091	$2,792,974	$2,123,884	$669,091
449	$3,504,196	$2,531,592	$972,605	$3,504,196	$2,531,592	$972,605
Totals	**Benefits**	**Costs**	**Net Benefits**	**Benefits**	**Costs**	**Net Benefits**
	$342,927,515	$141,645,449	$201,282,061	$273,368,751	$141,645,449	$131,723,308

SOUTH PROJECT AREA

Alternative	PV Total Benefits	PV Total Costs	PV Total Net Benefits
13/25	$258.1	$134.1	$124.0
13/50	**$273.4**	**$142.1**	**$131.3 (NED Plan)**
15/50	$283.5	$155.6	$127.9

NORTH PROJECT AREA

Alternative	PV Total Benefits	PV Total Costs	PV Total Net Benefits
13/25	$109.9	$ 95.8	$ 14.3
13/50	**$114.9**	**$ 99.1**	**$ 15.8 (NED Plan)**
15/50	$117.0	$105.0	$ 12.0

Economics of the NED Plan. Table 2 compares the expected annual benefits and costs and computes the benefit-to-cost data for the13/50 dune and berm plan, i.e., NED Plan. As shown in table 2, the benefit-to-cost ratio for the North Project Area, South Project Area, and total project are all favorable at 1.3, 1.9, and 1.7, respectively. The feasibility report describes how risk and uncertainty principles are incorporated in the GRANDUC model, and the degree of risk that the two project segments have a favorable benefit-to-cost ratio. For instance, there is a 99.9 percent chance that the South Project NED Plan has a favorable benefit-to-cost ratio, while the North Project has a 76.7 percent chance.

TABLE 2. Economic Sensitivity of the NED Plan

Summary of Project Economics	North Project	South Project	Total Project
Total Initial Construction	**$22,713,000**	**$48,961,000**	**$71,674,000**
Interest During Construction	$ 4,181,000	$ 5,920,000	$10,101,000
Total Investment Cost	**$26,894,000**	**$54,881,000**	**$81,775,000**
Expected Annual Cost			
Int. & Amort @ 6-5/8%-50 yrs.	$1,856,900	$ 3,789,200	$ 5,646,100
Period Nourishment	$5,251,500	$ 6,521,800	$11,773,300
Other Annual Costs	$ 200,000	$ 600,000	$ 800,000
Annual Environmental Monitoring	$ 4,600	$ 10,800	$ 15,400
Total Expected Annual Cost	**$7,313,000**	**$10,921,800**	**$18,234,800**
Total Expected Annual Benefits	**$9,309,600**	**$21,170,100**	**$30,479,700**
Net Benefits	**$1,996,600**	**$10,248,300**	**$12,244,900**
Benefit-to-Cost Ratio	**1.3**	**1.9**	**1.7**

Damage Indicator Sensitivity Test

Use of a 6-inch vertical erosion indicator has been criticized and hopefully some of the efforts of the Institute for Water Resources (IWR) and data collection from new storm events will provide a better data set to validate or modify erosion indicators for shore protection projects. In the meantime, we offer the following sensitivity analysis for the indicators used in the Dare County study. The damage indicator used in the erosion damage curves was the location of the 1/2 foot of vertical erosion. The distances used to check for structure undermining were measured from the toe of the dune. To test the sensitivity of benefits to the damage indicator used, runs were made with percentages of the distance to the 1/2 foot of vertical erosion. For example, in figure 1 instead of using the 185 foot location to check for structure undermining the 70 foot location would be used instead.

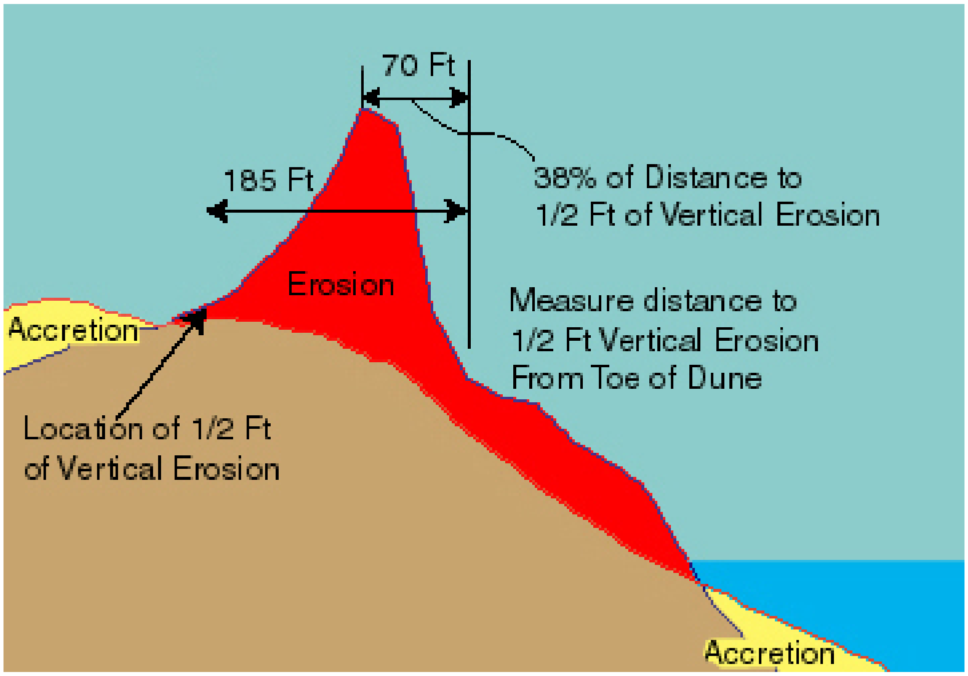


Figure 1. Example of a percentage of indicator distance.

Figure 2 is a graph of benefits calculated using various percentages of the distance to the location of 1/2 foot of vertical erosion to determine structure undermining for the South Project. The point at which the project cost line ($142,000,000) crosses the curve is the project break even point (38%).

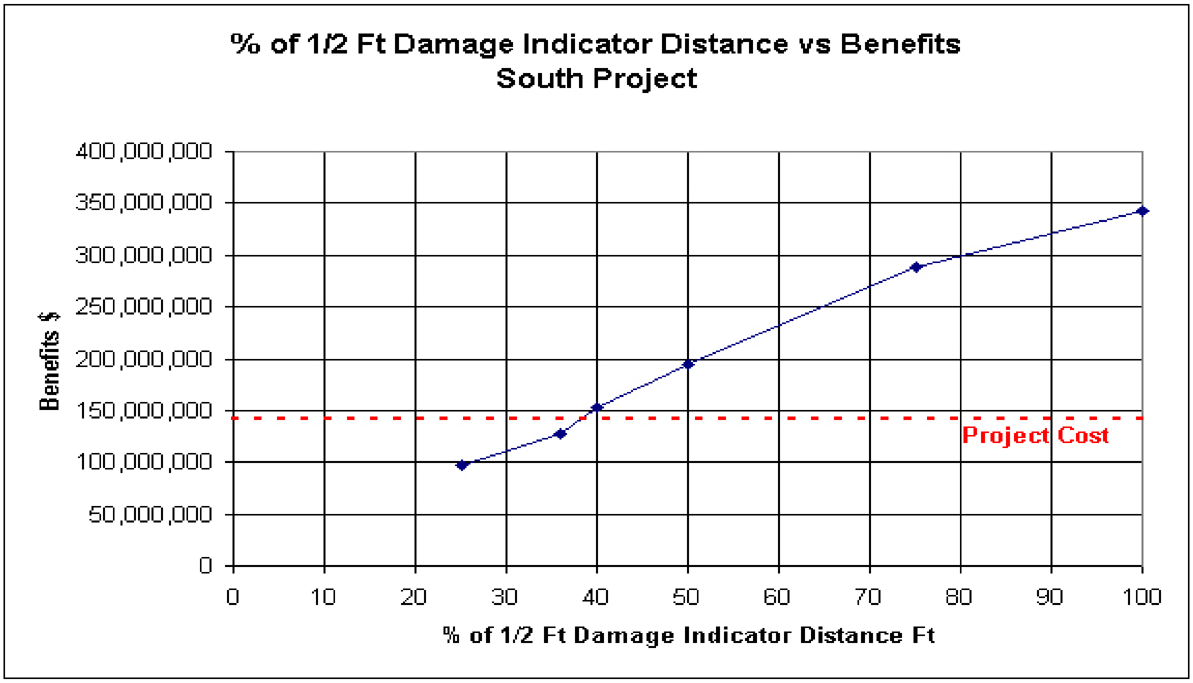


Figure 2. Graph of Various Percentages of the Distance to 1/2 Foot of Vertical Erosion Damage Indicator versus Benefits for the South Project.

Figure 3 is a graph of benefits calculated using various percentages of the distance to the location of 1/2 foot of vertical erosion to determine structure undermining for the North Project. The point at which the project cost line ($99,100,000) crosses the curve is the project break even point (75%).

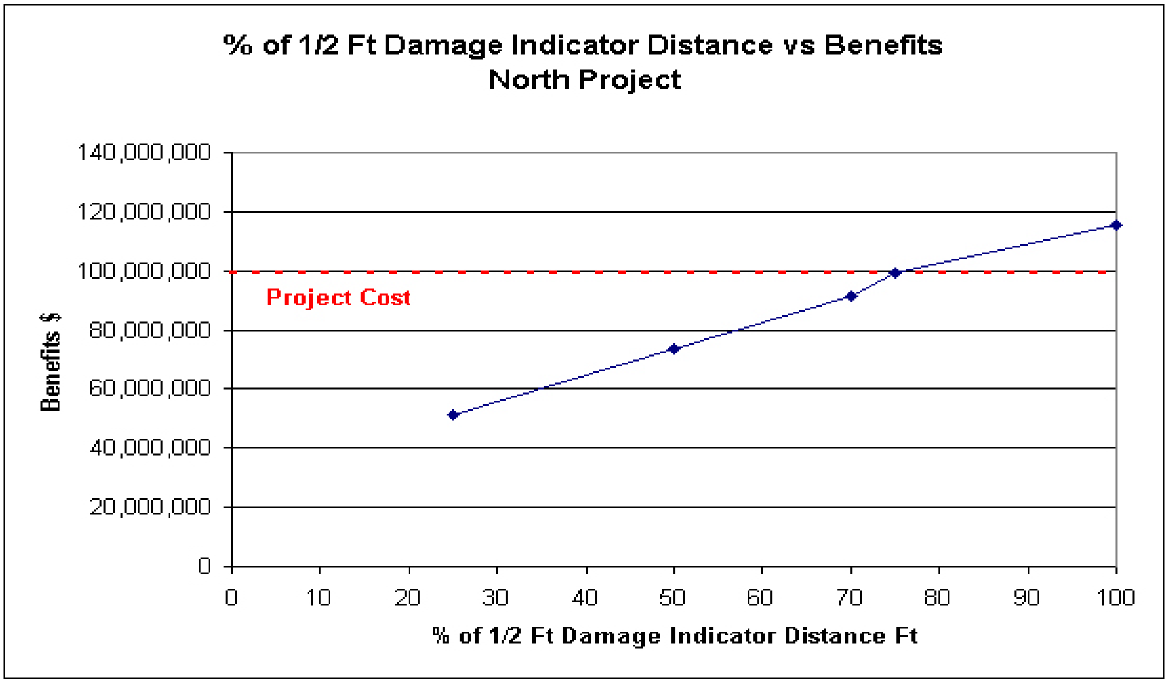


Figure 3. Graph of Various Percentages of the Distance to 1/2 Foot of Vertical Erosion Damage Indicator versus Benefits for the North Project.

Figures 4 and 5 are examples of the 38% distance for the 100 year storm located on two of the typical profiles used in the study.

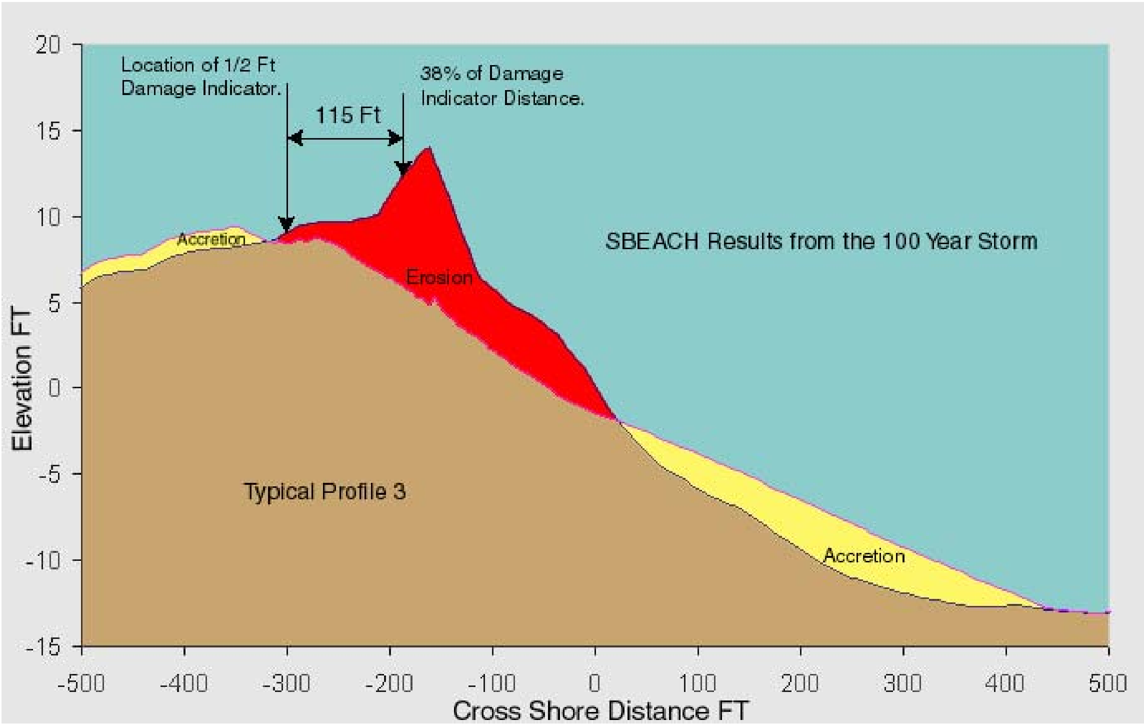


Figure 4. The 38% Distance Located on Typical Profile 3 for the 100 Year Storm.

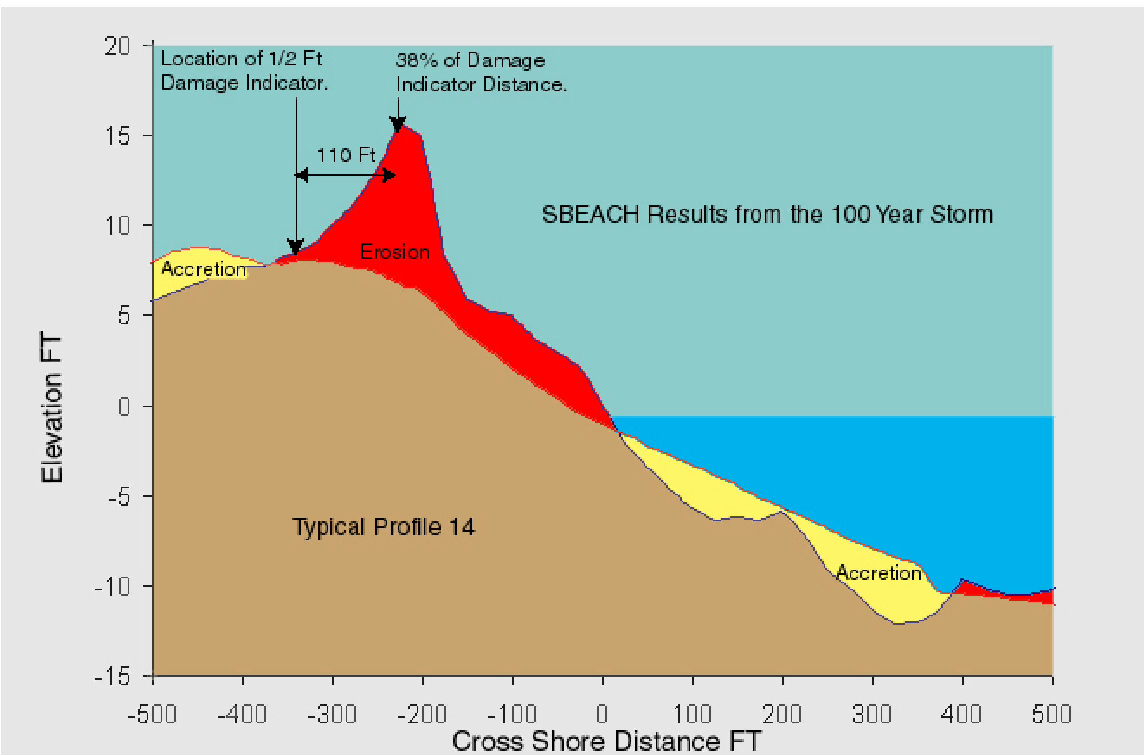


Figure 5. The 38% Distance Located on Typical Profile 14 for the 100 Year Storm.

Figures 6 and 7 are examples of the 75% distance for the 100 year storm located on two of the typical profiles used in the study.

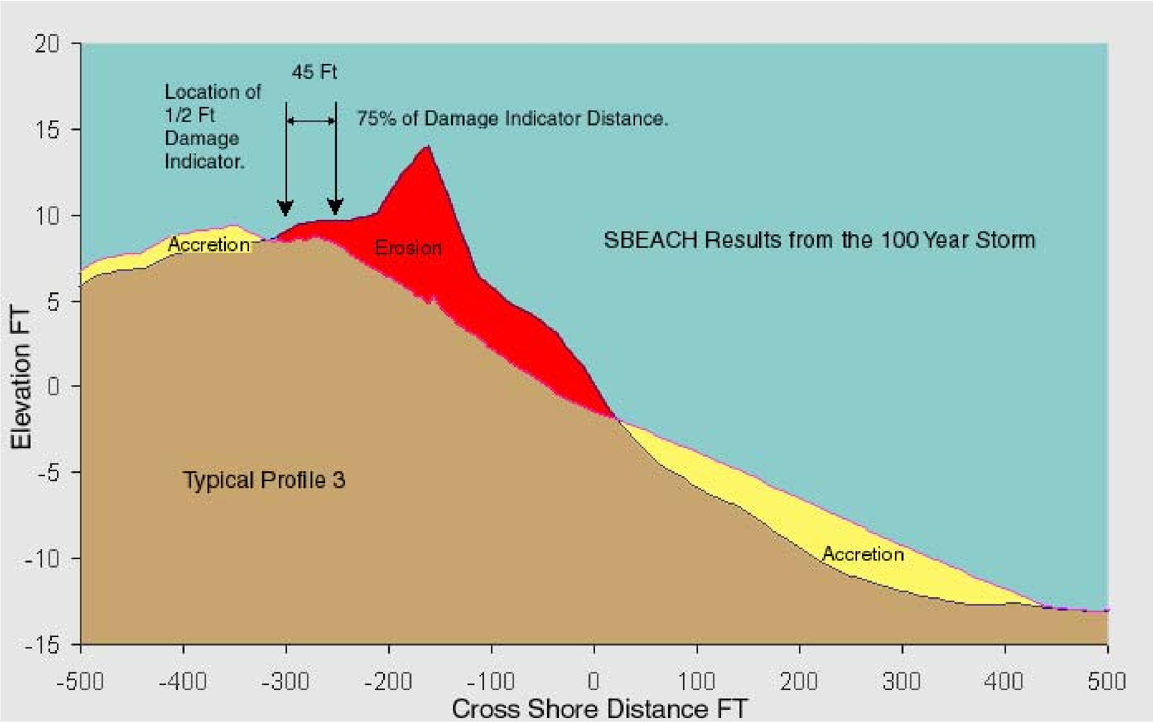


Figure 6. The 75% Distance Located on Typical Profile 3 for the 100 Year Storm.

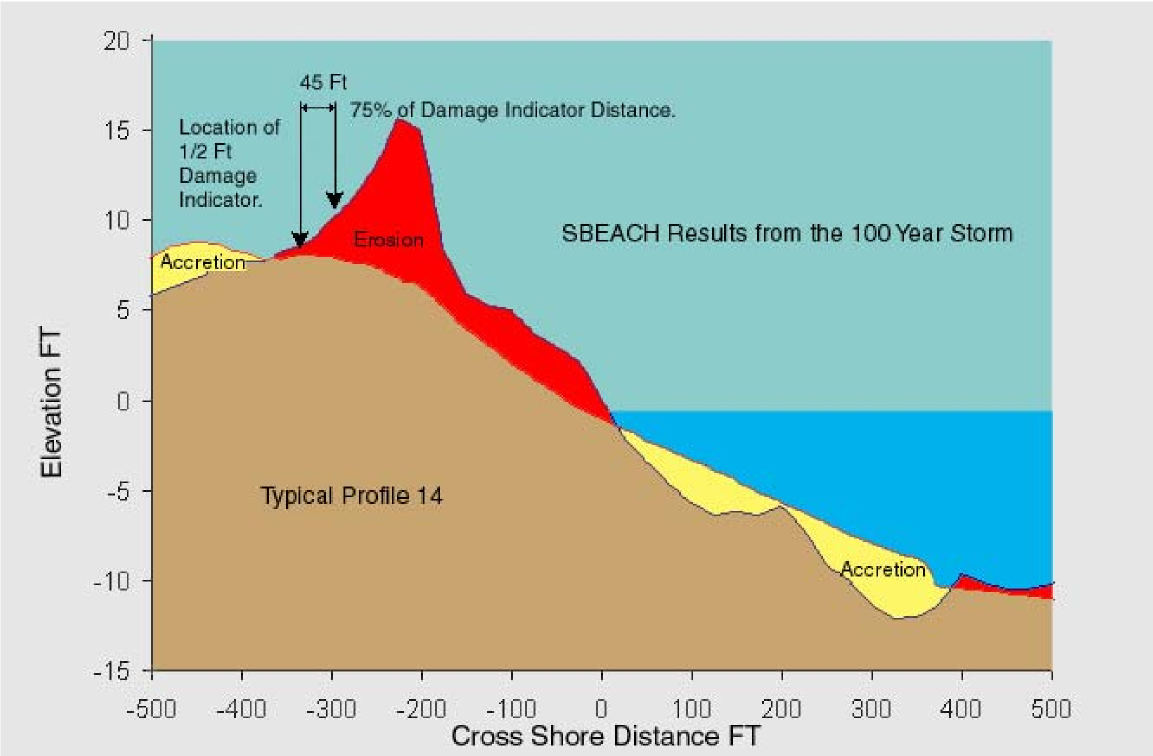


Figure 7. The 75% Distance Located on Typical Profile 14 for the 100 Year Storm.

Conclusion. Regarding horizontal erosion, we can conclude from this sensitivity analysis that in the case of the North Project, we could have overestimated damages using the 1/2-ft indicator by as much as 25% and still have a justified project. And, in the case of the South Project, we could have overestimated damages using the 1/2-ft indicator by as much as 62% and still have a justified project. Or, said differently, we would still have a justified North Project if the critical damage point was 75% of the distance we originally estimated. And, we would still have a justified South Project if the critical damage point was 38% of the distance we originally estimated.

Regarding the vertical erosion indicator, we have shown that a greater vertical distance could have been used and still resulted in a justified project. The District still believes that the 6-inch indicator serves as a useful and reasonable proxy of when the building is subjected to the full brunt of the storm including direct wave impact and inundation, and that we have modeled an accurate depiction of the expected annual damages for the study area.

Comparison of Sensitivity Analysis and Feasibility Report

The NED Plan remains the same as that recommended in the Feasibility Report. This sensitivity analysis changed only the erosion damage curves used to compute the hurricane and storm damage reduction benefits. It showed that conservative revisions to these curves did not change the design or lateral extent of the NED plan. A previous sensitivity using a composite erosion damage curve from several coastal districts put together by headquarters also showed that the plan remained feasible and correctly formulated. These analyses were done at an interest rate of 6 5/8 percent and October 1999 price level. The Feasibility Report analysis is given below in table 3.

TABLE 3. Economics of the NED Plan

Summary of Project Economics	North Project	South Project	Total Project
Total Initial Construction	**$22,713,000**	**$48,961,000**	**$71,674,000**
Interest During Construction	$ 4,181,000	$ 5,920,000	$10,101,000
Total Investment Cost	**$26,894,000**	**$54,881,000**	**$81,775,000**
Expected Annual Cost			
Int. & Amort @ 6-5/8%-50 yrs.	$1,856,900	$ 3,789,200	$ 5,646,100

TABLE 3. Economics of the NED Plan – continued

Summary of Project Economics	North Project	South Project	Total Project
Period Nourishment	$5,251,500	$ 6,521,800	$11,773,300
Other Annual Costs	$ 200,000	$ 600,000	$ 800,000
Annual Environmental Monitoring	$ 4,600	$ 10,800	$ 15,400
Total Expected Annual Cost	**$7,313,000**	**$10,921,800**	**$18,234,800**
Total Expected Annual Benefits	**$9,309,600**	**$26,092,700**	**$35,402,300**
Net Benefits	**$1,996,600**	**$15,170,900**	**$17,167,500**
Benefit-to-Cost Ratio	**1.3**	**2.4**	**1.9**

Summary of the NED Plan. The NED Plan, as presented in the Feasibility Report, consists of two distinct dune and berm projects with the berm to be constructed at elevation 7.0 feet NVGD and a width of 50 feet measured from the toe of the constructed dune. The top of dune elevation is to be 13 feet NGVD. The South Project Area is about 10.1 miles long including 3,000-foot long transition zones on the north end and a 2,850 foot long transition zone on the southern end near the National Park Service property. Its northern transition zone begins near Blackman Street in North Nags Head to the southern limit of South Nags Head. The South Project will cost about $48.9 million to construct and has a benefit-to-cost ratio of 2.4. The North Project Area is about 4.1 miles long including 3,000-foot long transition zones on each end. From its northern transition zone to its southern transition zone, the North Project Area runs from about 500 feet south of Historic Street in Kitty Hawk to the vicinity of Woodmere Avenue in Kill Devil Hills. The North Project will cost about $22.7 million to construct and has a benefit-to-cost ratio of 1.3. The overall benefit-to cost ratio for the entire project is 1.9, and it will cost about $71.7 million to construct. With no locally preferred plan identified by the non-federal sponsor, the NED Plan is the recommended plan.

Effectiveness of the NED Plan. For the overall primary study area, the effectiveness of the NED Plan at reducing hurricane and storm damages is about 72 percent (1 – $10,511,000 / $37,863,000)). The residual expected annual damages along the 20 miles of shoreline are estimated at $10,511,000.

The effectiveness of the NED Plan at reducing hurricane and storm damages for just the area protected by the project is about 84 percent (1 - ($5,026,000 / $32,374,000)). The residual expected annual damages along the shoreline protected by the project are estimated to be $5,026,000.

Strategic Planning Meeting. Representatives of the Wilmington District, South Atlantic Division, Headquarters USACE, and Dare County held a Strategic Planning Meeting on September 23, 2004. The purpose of the meeting was to achieve concensus in resolving HQ Policy Review Comments dated 20 August 2004 relative to the conditions in the Chief's Report. Minutes of that meeting are included as attachment 2.

Additional Sensitivity Analyses of the Erosion Damage Curve. As a result of discussions at the Strategic Planning Meeting on September 23, 2004, the district performed additional sensitivity tests of the erosion-damage curves. The decision at the meeting was that "Using GRANDUC, SAW should conduct a sensitivity analyses of a single curve (band of uncertainty) and thoroughly describe the results of the analyses."

Figure 1 contains a plot of the primary erosion damage used in the Dare County Beaches Economic Analysis.

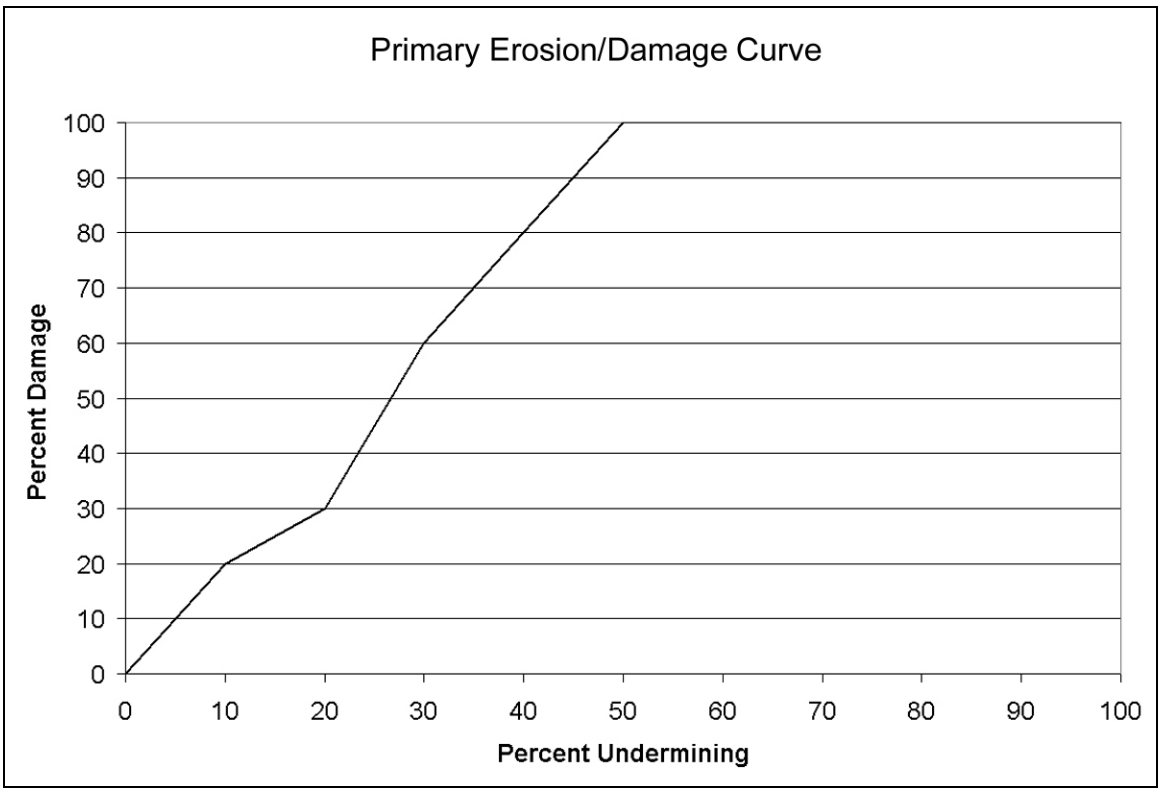


Figure 1 Primary Erosion Curve.

To test the sensitivity of the economic analysis to the erosion/damage curve that is used, the curve was uniformly shifted to the right, which increases the percent undermining while holding the percent damage constant, and then the economic analysis was re-run.

Figure 2 contains the range of curves that were tested, for the North Project, with the beginning and ending benefit cost ratios (BCRs.)

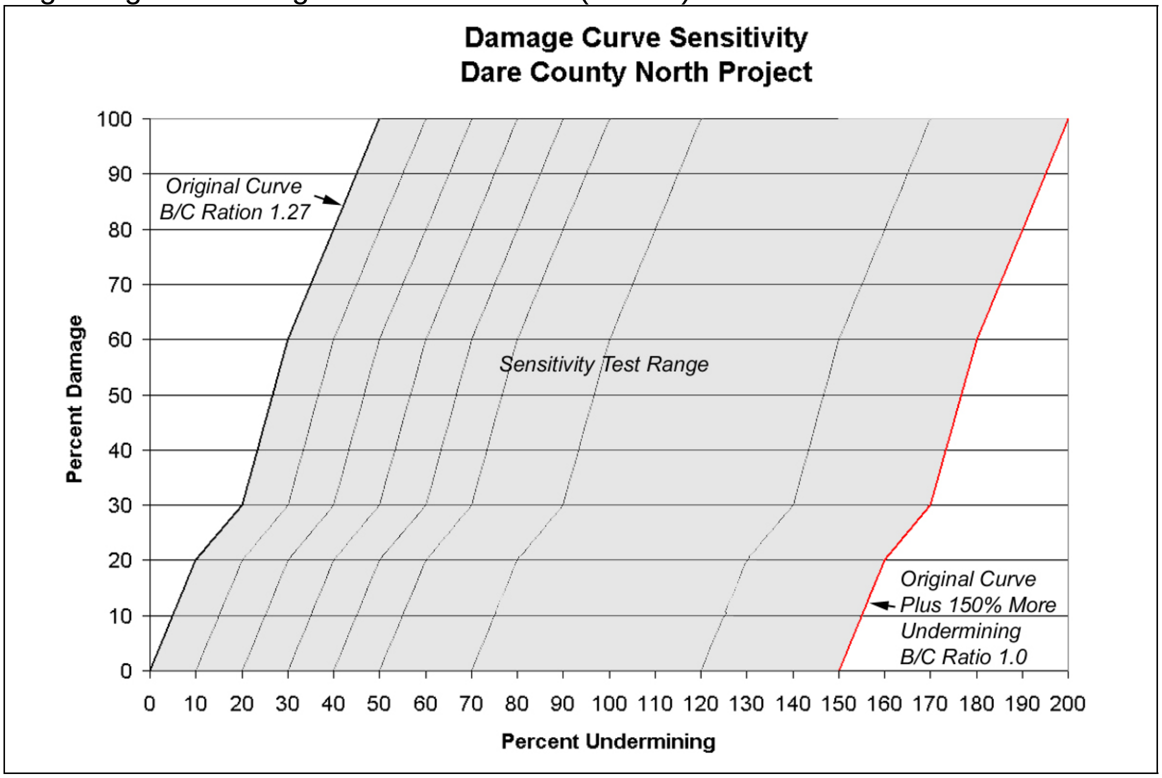


Figure 2 Damage Curve Sensitivity, North Project.

The percent undermining for the north project erosion/damage curve can be increase by 150% before the North Project's BCR drops to 1.0.

The results for a similar analysis of the south project are shown in figure 3. It should be noted that the same original curve is used in both figures 2 and 3 but range of the abscissa is more than doubled in figure 3. When the percent undermining for the erosion/damage curve used for the south project was increased by 400% the BCR dropped to 1.24 and the increase in percent undermining from 300 to 400% only dropped the BCR by 0.02. This indicates that the south project is less sensitive to the erosion damage curve used than the north project. Of the other damage mechanisms, which are wave damage, flood damage, land loss and long term erosion damage, the locations of the higher valued structures of the south project make long term erosion the likely reason for the south project less sensitive to the erosion/damage curve than the north project.

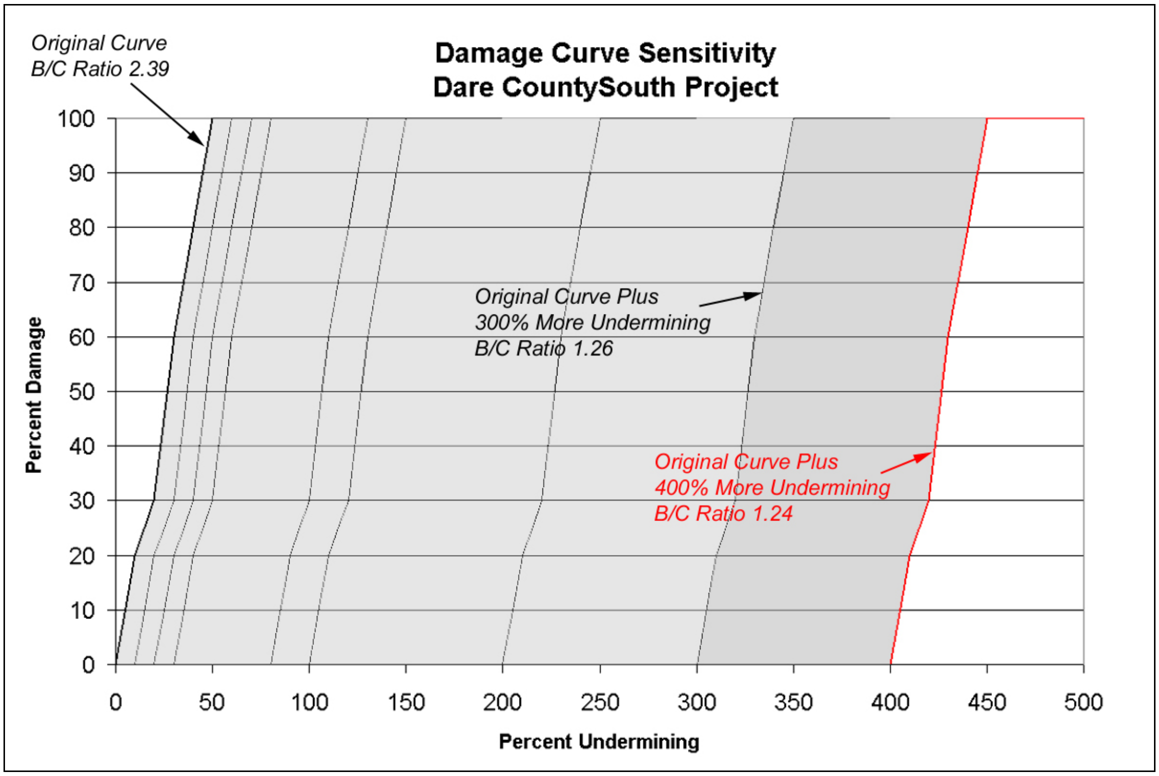


Figure 3 Damage Curve Sensitivity, South Project.

Figure 4 contains a plot of the intermediate results for the sensitivity runs for both the north and south projects.

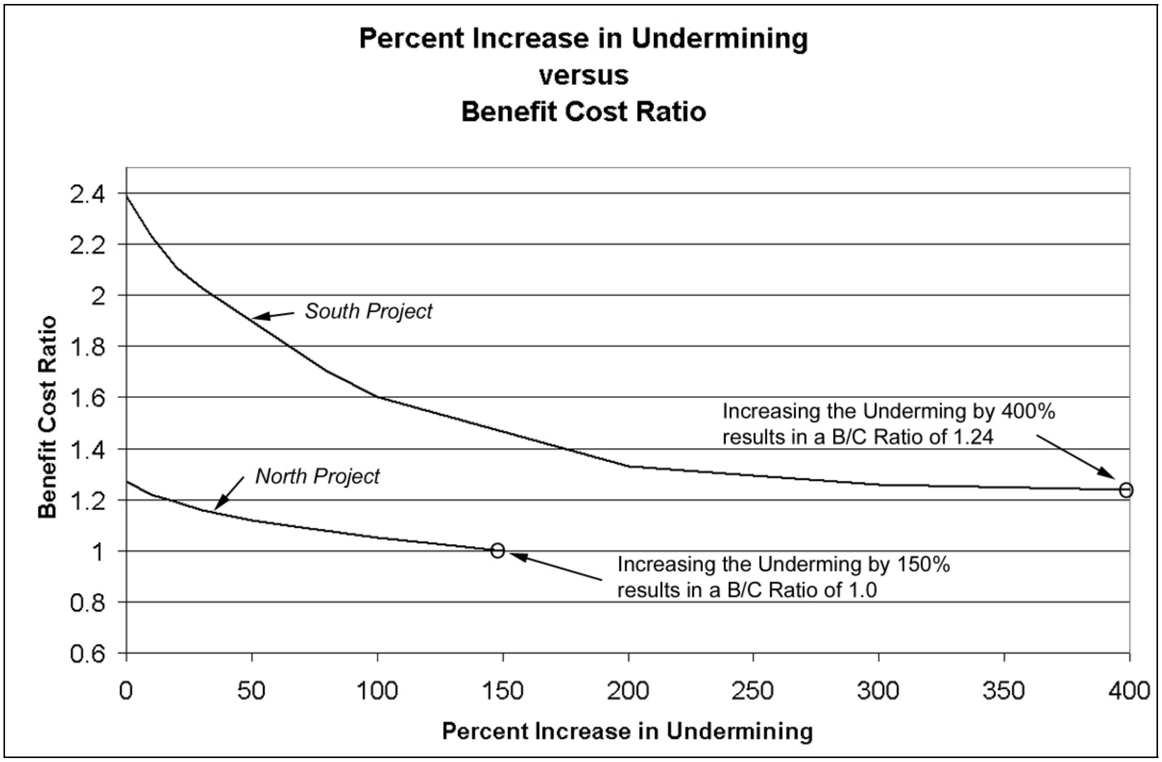


Figure 4 Percent Increase in Undermining versus Benefit Cost Ratio.

Technical Review of the Sensitivity Analysis. As a result of discussions at the Strategic Planning Meeting, the district requested assistance from the Hurricane and Storm Damage Center of Expertise in the North Atlantic Division. The review was performed by Mr.Randy Wise, Coastal Engineer, and Mr. Robert Selsor, Economist, of the Philadelphia District. They reviewed both the erosion indicator and the erosion damage curves in light of their experience in similar studies. Their two main conclusions were that the Philadelphia District uses the same damage indicator and uses an erosion damage curve that is more conservative than our original curve but falls within our sensitivity range. Their curve is closer to our original curve than the upper bound of our sensitivity range and is more aggressive than the Cone Curve we used for another sensitivity test. Their review and assessment is attached as attachment 3.

PUBLIC ACCESS

Dare County, the non-Federal sponsor, is currently developing a plan for access and parking to satisfy our access requirement. They are committed to this action and expect full compliance with our requirement (Dare County letter is shown as attachment 4). The details and 100% non-federal costs for access will be documented in the PCA, which is scheduled for December 2004. A map of the existing and planned access points and parking is also shown as attachment 4.

CONTINUED ENVIRONMENTAL COORDINATION

To address this condition the District embarked on a series of stakeholder meetings to include all interested resource agencies and beach communities. The meetings were structured to address the major concerns expressed during review of the Dare County Beaches Feasibility Report and Final Environmental Impact Statement. Major issues addressed included, economic analysis, GRANDUC modeling, cumulative impact analysis, monitoring requirements and real estate.

In addition, the District has worked with other Districts, ERDC, and resource agencies to develop a comprehensive monitoring plan for implementation during PED. The plan is intended to demonstrate reasonable recovery of benthic food sources in the borrow area and to identify any unforeseen significant impacts on habitat and/or indicator species. The plan will consider results from ongoing monitoring studies at Brunswick County, NC and recent findings of the New York District as part of a 7-year monitoring effort on New Jersey beaches. It will identify reasonable and prudent investigations that will establish baseline conditions, and assess construction, short term, and long term impacts on habitat and/or indicator species.

Stakeholders Meetings

In March 2001, the Wilmington District began a series of meetings that included interested parties from beach communities, State and Federal agencies, environmental interest groups, and other interested public. The purpose of the meetings was to provide a forum for discussion of issues related to shore protection needs in North Carolina. The first meeting held on 22 and 23 March, 2001, was structured as an overview of the Corps project management business process, planning process, economic analysis process for shore protection projects, and the GRANDUC model (general risk and uncertainty analysis). The meeting was also used to develop topics of interest for future meetings and to develop a schedule for future meetings. All of the meetings to date have been well attended and supported by staff form the South Atlantic Division office, USACE, the Institute for Water Resources, and Engineer Research and Development Center. Wilmington District intends to continue the dialogue with coastal stakeholders on an annual basis. A brief summary of each of the workshops is provided in the following paragraphs.

First Meeting, "Corps Procedures for Shore Protection Projects", 22-23 March 2001. The U.S. Fish and Wildlife Service expressed a keen interest in learning more about how the Corps performs coastal engineering and economic analysis as part of shore protection projects. Their interest was born from concerns about these topics as described in the Dare County Beaches, North Carolina (Bodie Island Portion) Feasibility Report and Final Environmental Impact Statement. In the December 2000 Chief's Report, recommending the project to Congress, the District Engineer was directed to "*continue to coordinate with environmental resource agencies and environmental protection advocacy groups during the PED phase of the project to address their* *concerns and will conduct studies or other activities as necessary*." To put the discussion topics in proper context, the first afternoon was spent addressing the Project Management Business Process and the Planning Process. The second day featured presentations and follow-up discussions on our economic analysis process for shore protection and an overview of the GRANDUC model. Wilbert Paynes from SAD and Harry Shoudy from USACE participated in the presentation and discussions.

Second Meeting, "Cumulative Impacts and Benefit Analysis", 25-26 April 2001. A major concern among some of the resource agencies and environmental interest groups is the extent of beach erosion and associated shore protection projects in North Carolina. In a few years, the State has gone from approximately 14 miles of shore protection projects (existing) to a potential of over 110 miles of shore protection (authorized studies). The concern is related to the perceived cumulative impact of coastal projects on coastal resources. Again, this was a specific concern addressed by the U.S. Fish and Wildlife Service during the Dare County Beaches Project. The second workshop included presentations from the District, the North Carolina Division of Coastal Management, and the U.S. Fish and Wildlife Service on the subject of cumulative impact assessment. Topics addressed were policy and guidelines, methodologies, and specific examples for shore protection projects. The District's presentation focused on our compliance with NEPA guidelines for cumulative impact assessment and the extensive effort to include all shore projects in the assessment for Dare County Beaches. We believe that the Dare County example represents the right level of detail and we plan to use it as a template for future work. Resource agency presentations tended to focus more on comprehensive coastal management planning as opposed to project-by-project analysis.

The second part of the workshop dealt with the Corps evaluation and accounting methods for regional economic benefits and other social effects. This was of particular interest to the beach communities. They believe a lot of the benefits of shore protection projects are not captured in our NED analysis. Presenters included District staff and a representative from the North Carolina Shore and Beach Preservation Association.

Third Meeting, "Comprehensive Coastal Planning", 30 May 2001. As a follow-up to our discussion on cumulative impact assessments and an interest from some of the resource agencies in the development of a Programmatic Environmental Impact Statement for coastal projects, the third workshop focused on the need for and mechanics for development of a statewide comprehensive coastal management plan. Given the increased need for and interest in shore protection, increased development of the State's coastline, the concern about cumulative resource impacts, pressure on available sand sources, and increased funding requirements, there is State and Federal interest in taking a more holistic approach to the State's coastline. The meeting was conducted as an open forum for sharing of information and discussions from other similar initiatives in the State of North Carolina and Florida. As a result of discussions, a sub-committee chaired by the Mayor of Caswell Beach in Brunswick County, was established to further develop ideas and strategies to pursue the initiation of a management plan. The sub-committee is made up of non-Federal interests with the

Corps and the USFWS acting as advisors. Their primary task is to examine on-going initiatives, develop the merits for a comprehensive approach to coastal resource management, and develop a strategy for a State led initiative.

Fourth Meeting, "GRANDUC and Environmental Monitoring", 23-24 October 2001. The fourth workshop provided a recap of the earlier workshops and included a detailed presentation by Corps staff on our coastal and economic models. Dave Moser from IWR and Harry Shoudy assisted in these presentations. Bob Berman, an economist with the Department of Interior attended and probed the mechanics of GRANDUC with the presenters. The second day of the workshop featured presentations from the North Carolina Division of Coastal Management on their program for coastal management, beach community presentations on the sponsor economic viewpoint, and a presentation from ERDC on the results of a 7-year monitoring study done for the New York District (shore protection project). The results of this long term monitoring effort were that there were no long term impacts to benthic or fish resources in nearshore areas of the beach nourishment areas or in offshore borrow areas. Any temporary increases in turbidity were quickly diminished and recovery of impacted resources was rapid.

Fifth Meeting, "Real Estate", 1 July 2002. The fifth workshop featured a visit from General Flowers who held a question and answer session for the stakeholders. This was followed up by presentations and discussion of real estate requirements for shore protection projects. The discussion addressed the content and timing of easements, non-federal responsibilities, crediting for land, easements, and right of ways, and implications of beach nourishment projects on private versus public lands and requirements for public access.

Sixth Meeting, Regional Sediment Management, 13 November 2003. The sixth meeting was held in conjunction with the North Carolina Shore and Beach Association conference. The meeting was organized in response to state and other stakeholder interests in pursuing Regional Sediment Management (RSM). Attendees included state and local agency/interests who are interested in opportunities to get sand placed on eroding beaches or into the littoral system. Lynn Martin from IWR presented a National overview of RSM, John McCormick from Wilmington District presented a District perspective, and Steve Aiken from Wilmington District presented budget opportunities, realities, and constraints. Ideas for funding RSM in North Carolina included getting demo funds, as well as getting a GI study funded for the entire North Carolina coast, such as approved for New Jersey. There was also discussion of pursuing some of the opportunities that exist now with ongoing feasibility studies. The development or update of Dredged Material Management Plans was discussed as an option for addressing sediment management but reduced O&M funding levels was identified as an impediment.

Monitoring Plan

In an effort to resolve outstanding issues related to potential impacts on environmental resources, the District engaged all interested resource agencies in the development of a comprehensive monitoring plan for the shore protection project. The plan is intended to demonstrate reasonable recovery of benthic food sources in the borrow area and to identify any unforeseen significant impacts on habitat and/or indicator species. Key agencies that participated in the development of the plan included the U.S. Fish and Wildlife Service, National Marine Fisheries Service, the North Carolina Division of Marine Fisheries, and the North Carolina Division of Coastal Management. Monitoring includes physical and biological measurements. Three public/agency meetings were held regarding preparation of the monitoring plan. The draft monitoring plan was presented at the last meeting on December 2, 2003. There was good attendance and participation at each meeting. Based on comments received during and after this last meeting, the final monitoring plan was prepared and provided to all interested parties on February 20, 2004. This monitoring plan is provided as attachment 5. The monitoring began in May 2004, and to date the spring and summer 2004 events are complete.

While we have been very effective at addressing many of the concerns about the project and the agencies are satisfied with the monitoring plan, it should be understood that the stated positions of the resource agencies regarding beach nourishment, including this project, have not changed. The agencies agree that the results of the monitoring activities will provide extremely valuable information to help address future shore protection projects and renourishment actions.

CONCLUSION

This addendum has addressed the remaining conditions contained in the Chief's Report. The erosion damage curves were modified to reflect the best available data and damage indicators were subjected to a sensitivity analysis. The treatment of structure replacement assumptions remains consistent with the management policies of the North Carolina Division of Coastal Management. All public access requirements will be met and outlined in the Project Cooperation Agreement (PCA). While most of the environmental resource agencies still have basic concerns about impacts of shore protection projects, they are very supportive of the proposed monitoring plan and excited about the data that will be provided. The project continues to have strong sponsor support. In summary, we find that the recommended project in the feasibility report still meets the original project objectives, is economically feasible, still represents the NED plan, and is environmentally sound.

Attachment 1

NORTH CAROLINA SEA GRANT
EXTENSION PROGRAM

Sea Grant North Carolina

5001 Masonboro Loop Road Wilmington, N.C. 28409
Telephone: 910/962-2491 • Fax: 910/962-2410
rogerssp@uncwil.edu

To: Coleman Long
Chief, Planning & Environmental Branch
Wilmington District USA-COE

From: Spencer Rogers S.M. Rogers, Jr.

Date: June 8, 2004
Subject: Review of damage curves for Dare County Study

As requested, I have reviewed the damage curves used in the Addendum to the Dare County Beaches Final Feasibility Report and have discussed the modeling methods with the Wilmington District staff. The revised curves are identical or very close to most of the curves I suggested in "Erosion Damage Thresholds in North Carolina" (April 21, 2002). The only obvious difference is the method which underhouse enclosures are addressed. I suggested a single underhouse enclosure curve, applied independently from the attached piling-supported building. The method used by the District in the Addendum combines enclosure losses into multiple curves for lower floors with various enclosure size and finish combinations. The consequence is many more damage curves but significantly fewer structures to analyze in each model run. The approach is more complex but is a potentially more efficient computational approach. The district's combined curves for enclosures and piling-supported buildings appear to reasonably represent the separate building and enclosure curves suggested in my report.

Since my report was written, I participated in a FEMA/NC Emergency Management Hazard Mitigation Technical Assistance Program project that conducted detailed damage surveys on coastal buildings in Dare County, including the two Corps study areas, following Hurricane Isabel in 2003. Analysis of the collected data may eventually lead to erosion damage curves based on storm data rather than professional judgement, the only option available at this time. However, any useful results will take several years of additional research. First impressions following the damage inspections do not suggest any significant changes in my earlier report.

Much of the development in the study area has been experiencing long-term erosion for decades. Isabel's field work indicated that few of the undermined buildings in the study areas have been constructed since 1986, when longer, more erosion-resistant foundations were implemented by the North Carolina State Building Code. As progressive erosion has gradually undermined older buildings, property owners have modified the original shallow piling foundations. As each row has been undermined during small storms, the pilings have been replaced or bolted to new, deeper pilings (sistered). Any pilings not exposed by prior erosion cannot be easily accessed for improvement. The foundation renovations result in buildings more erosion-tolerant than the typical pre-1986 but unless the entire building has been previously eroded, less erosion-tolerant than buildings constructed since 1986.

My report did not address curves for renovated piling foundations. The Addendum sensitivity test shifted 6% of the North Project buildings and 19% of the South Project buildings to the more erosion-tolerant curves for buildings since 1986. It is my impression from the post-Isabel field work that those changes significantly over-estimate the number of buildings constructed since 1986 but reasonably represent the total of newer and substantially renovated, older foundations. Because the foundation renovations are often incomplete, with the landward side of the building remaining on short pilings, using the erosion-tolerant curve should underestimate erosion damage in the next storm, probably significantly (several failed). The damage estimate is therefore conservatively low.

In summary the erosion damage curves used in the Addendum to the Dare County Beaches Final Feasibility Report appear to reasonably represent our present knowledge of storm-induced erosion damage to buildings in North Carolina. The sensitivity analysis in the Addendum increases my confidence in the final results. The erosion analysis changes in the Addendum appear to be steady improvements over the original study methods.

Please contact me if there are any questions on my comments. :

Attachment 2

PDT Meeting Minutes

Dare County Beaches (Bodie Island Portion)
Hurricane & Storm Damage Reduction Project

Subject: Dare County Beaches, North Carolina (Bodie Island) Final Feasibility Report and Environmental Impact Statement (September 2000), Chief's Report (December 2000), Letter Report (May 2003), Addendum (November 2003), Addendum Supplement (June 2004), Headquarters Policy Compliance Review Comments (August 2004)

Date:	September 23, 2004	
Time:	8:30 am – 3:30 pm	
Location:	U.S. Army Corps of Engineers, Wilmington District, Main Conference Room	
Attendees:	Ray Sturza	Dare County, NC, Planning Director
	Dave Moser	HQUSACE, Chief Economist
	Jay Warren	HQUSACE, Office of Water Project Review
	Charlie Chesnutt	USACE, IWR
	Wilbert Paynes	USACE, SAD, Chief, Planning
	Gerald Melton	USACE, SAD, Economist
	Ben Wood	USACE, SAW, DDEPM
	Hank Maser	USACE, SAW, Chief, TSD
	Sam Colella	USACE, SAW, Chief, Project Management
	Coleman Long	USACE, SAW, Chief, Planning & Environmental Branch
	Wayne Bissette	USACE, SAW, Chief, Engineering Branch
	Noel Clay	USACE, SAW, Chief, Planning Services Section
	Frank Reynolds	USACE, SAW, Economist
	Frank Snipes	USACE, SAW, Economist (Topsail, Surf City, North Topsail, Brunswick County Projects)
	Mike Wutkowski	USACE, SAW, Lead Coastal Engineer
	Sharon Haggett	USACE, SAW, Project Manager

PURPOSE: Achieve consensus in reaching a resolution to Headquarters Policy Compliance Review Comments dated 20 August 2004 relative to conditions of the Chief's Report dated 29 December 2000.

GOAL: Development of strategic plan to allow Wilmington District to include a funds request for the Dare County Beaches (Bodie Island Portion) Hurricane & Storm Damage Reduction Project in the FY2007 budget submittal.

After brief introductions, project history and review and discussion of damages experienced in the project area as a result of Hurricane Isabel (September 2003), Wilbert Paynes facilitated the discussion of the conditions as stated in item 7 of the referenced Chief's Report and reiterated below:

"7. Therefore, I recommend implementation of the project subject to the following conditions and with such modification as in the discretion of the Chief of Engineers may be advisable. During preconstruction engineering and design (PED) phase, the district will undertake studies to confirm or support revision of the erosion damage relationships used in the project economic analysis as a basis for identifying the national economic development plan and the Federal interest and participation in the recommended project. The district engineer will ensure that public access to all segments of the 14.2-mile-long project is consistent with law and regulation prior to initial construction and each nourishment. Finally, the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, and the National Marine Fisheries Service expressed concerns regarding the adequacy of the analysis of cumulative impacts; suitability of sand for beach nourishment; turbidity impacts on important fisheries; and impacts of sediment transport to Oregon Inlet. Several environmental protection advocacy organizations communicated similar concerns. The reporting officers will continue to coordinate with environmental resource agencies and

environmental protection advocacy groups during the PED phase of the project to address their concerns and will conduct studies or other activities as necessary."

The TEAM consensus is that the conditions as stated in the Chief's Report could be summarized in three broad topics and actions taken as described below to adequately address these items. These actions will be submitted as a revision to the Addendum Supplement dated June 2004 and will be considered a satisfactory response to the Headquarters Policy Review Comments dated August 20, 2004.

1) Stakeholder Status

SAW provides a more detailed status update of the series of stakeholder meetings that have occurred on this project. In addition to the previous stakeholder update, Include an in-depth discussion of the meetings that were held to develop both the biological and physical monitoring plans as well as references to what organizations where invited to participate in the development of the monitoring efforts. Basically, SAW needs to describe what we have done, what are we currently doing and what is the future plan of action and how can it be adapted as required in the future for best management practices of this project.
This information is included in the Addendum and the Final Monitoring Plan is included as attachment 5.

2) Public Access

In addition to including a copy of Dare County's letter of commitment to provide all necessary public access as required, provide a current GIS based map with existing accesses shown and proposed access locations.
The letter from Dare County and the GIS based map with existing and proposed accesses are shown as attachment 4.

3) Economic Analysis

Provide and in-depth thorough description (include types of items damages such as erosion, inundation and waves) of the damages captured in all of the damages curves utilized to date to include the initial "aggressive curve" and the "Cone-Smythe curve".

Using GRANDUC, SAW should conduct a sensitivity analyses of a single curve (band of uncertainty) and thoroughly describe the results of the analyses. Coordinate and request a review of this analysis by subject matter experts such as Lynn Bocamazo from New York District.
A discussion of damages and sensitivities of the erosion damage indicator and the Cone-Smythe curve is included in the Addendum. Also, an additional sensitivity of the erosion damage curve has been performed. This latest sensitivity was technically reviewed by the Philadelphia District in their role as the Hurricane and Storm Damage Center of Expertise.

It was also agreed the following schedule is the optimum to meet the project goals set out at the beginning of this meeting. The TEAM will work diligently to meet their individual commitments in anticipation of being able to include a funds request for this project in the FY2007 budget submittal. To further enhance the understanding of this project as it moves through the approval process, attendees agreed to be willing participants and that it will be invaluable to the project to involve the entire vertical TEAM in a full project briefing to the ASA(CW) as it is transmitted to that office.

Strategic Planning Meeting	23-Sep-04 (Actual)
SAW Submit Final Package to SAD/HQ	30-Oct-04
HQUSACE transmit to ASA(CW)	15-Nov-04
ASA(CW) Memo to OMB	02-Dec-04
OMB Letter to ASA(CW)	10-Jan-05
FEAS/EIS Report Approval by ASA(CW)	10-Feb-05
ASA(CW) Transmit Final FEAS/EIS Report Package to Congress	15-Feb-05

(Note: This means ASA(CW) has submitted Feasibility Report to OMB for their endorsement to Congress which will allow SAW to include in FY07 budget request)

HQUSACE Provide FY07 Budget Guidance	Mar-Apr 2005 (Typical)
SAW/SAD Prepare Budget Submission	May-Jun 2005 (Typical)

In addition to the above stated commitments, the following independent commitments were agreed upon but will not have an impact on the progress of the milestones as stated above.

A. Within 30 days of this strategic planning meeting (not later than 25 October 2004), Charlie Chesnutt and Dave Moser will provide SAW their assessment of the status of the post Hurricane Isabel analyses as well as their opinion as to whether or not anything can be extrapolated from this information to complement the Dare Addendum.

B. As a result of this meeting and the realization of the impacts of the policy review comments with regard to " … confirm or support revision of the erosion damage relationships used in the project economic analyses…" Charlie Chesnutt, IWR will engage representatives from HQUSACE (Jay Warren, Steve Cone, Doug Lamont, etc.) in a verbal dialogue to capture and communicate the philosophy of the technology development in the area of hurricane and storm damage reduction projects.

C. SAW will provide to SAD/Paynes an estimate of time and costs for the completion of an updated economic analysis to include an ITR by a subject matter expert such as Tom Smith with POD or Harry Shoudy. This costs and schedule will assume an immediate start of activities and will not be dependent on the receipt of any additional information from outside sources such as IWR and the Hurricane Isabel data.

Respectfully Submitted:

Sharon F. Haggett, P.E.
Project Manager
Dare County Beaches (Bodie Island Portion)
Hurricane & Storm Damage Reduction Project
U.S. Army Corps of Engineers,
Wilmington District
P.O. Box 1890
Wilmington, North Carolina 28402
(910) 251-4441

Attachment 3

27 October 2004

CENAP Review of the CESAW Primary Erosion-Damage Curve and Sensitivity Analyses for Dare County Beaches, North Carolina

CENAP staff reviewed material provided by CESAW in reference to the primary erosion-damage curve and sensitivity analyses applied in the Dare County Beaches, North Carolina (Bodie Island Portion) Feasibility Study. Documents provided to CENAP for review and as background information include: a summary document of the primary erosion-damage curve sensitivity analysis conducted by CESAW (herein referred to as the Summary); Addendum Supplement to the Dare County Beaches, North Carolina (Bodie Island Portion) Final Feasibility Report and Environmental Impact Statement, June 2004 (herein referred to as the Addendum); and the Final Feasibility Report and Environmental Impact Statement on Hurricane Protection and Beach Erosion Control – Dare County Beaches (Bodie Island Portion) Dare County, North Carolina.

The CENAP review focusses on three issues: how the primary erosion-damage curve applied by CESAW compares to the curve normally applied by CENAP for pile structures; whether the sensitivity analysis conducted by CESAW brackets the erosion-damage relationship used by CENAP; and whether site conditions along Dare County warrant use of a different curve than that normally applied by CENAP.

A direct comparison of different erosion-damage curves requires consistent definition of erosion indicators. The erosion indicator (0.5 ft of vertical erosion) applied by CESAW matches the criteria used by CENAP. Therefore, the definition of “percent undermining” is equivalent between the two District approaches, and the erosion-damage curves can be directly compared. The primary erosion-damage curve used by CESAW assumes 100% damage at 50% undermining, whereas the CENAP curve for pile structures does not assume 100% damage until 100% undermining. The CENAP curve is more comparable to the "Cone/Smyth" erosion-damage curve for pile foundation structures (discussed in the Addendum). The CESAW primary erosion-damage curve is more aggressive than what CENAP would normally use for pile structures.

As presented in the Summary, the sensitivity analysis applied to the CESAW primary erosion-damage curve increases the conservativeness of the erosion-damage calculations for both the South and North Projects. The CENAP erosion-damage curve falls within the limits of the test ranges shown in Figures 2 and 3 of the Summary. In examining the full range of the sensitivity tests, the CENAP curve is much closer to the original curve than the upper (conservative) limit of the test ranges. Therefore, although the original CESAW curve is more aggressive than the CENAP curve, the sensitivity tests cover a range that brackets the CENAP curve and reasonably addresses any uncertainty regarding potential overestimates of erosion damage.

The Addendum is helpful in reviewing actual storm damages in Dare County for structures situated on different beach and dune profiles. The photos and discussion strengthen the case for applying the more aggressive CESAW erosion-damage curve for structures founded on high dunes. As a comparison, in CENAP studies along the New Jersey and Delaware coastlines, first row structures are almost exclusively situated on a flat beach or lower dune profile located completely behind the primary dune. The documentation of storm damage shown in the Addendum supports our experience regarding dune response to storms. Dunes provide effective protection by significantly reducing wave, flooding, and erosion damage to backing structures; however, when attacked by storm surge, dunes will vertically erode more rapidly than flat beach profiles due to scarping and overwash. CENAP agrees failure would occur at a lower percent undermining for structures with shallow piles (8 ft below grade) situated atop high dunes than for equivalent structures situated on flat beach profiles, such as normally evaluated in our studies. Although CENAP cannot quantitatively confirm the level of accuracy represented by the CESAW primary erosion-damage curve in this scenario, our experience indicates that the CENAP curve would tend to be conservative when applied to structures founded on high dunes similar to those that exist in the Dare County study area.

Any questions regarding these review comments can be directed to Mr. Randy Wise, P.E., Coastal Engineer, NAD Regional Technical Specialist at tel: 215-656-6890, email: randall.a.wise@usace.army.mil; or Mr. Bob Selsor, Chief, Economics Branch at tel: 215-656-6569, email robert.e.selsor@usace.army.mil.

Attachment 4

Dare County
Administration Building
PO Box 1000

Planning Department

COUNTY OF DARE
MANTEO, NORTH CAROLINA 27954

MEMORANDUM

To. Sharon Haggett, USACE, Wilmington District

FROM Ray Sturza, Dare County Planning Director

DATE: November 30, 2000

RF: Public Beach Access in Project Area

It has come to my attention that the issue of public beach access in portions of the project area of the Northern Due Beaches Hurricane Protection and Erosion Control Plan has been raised during the comment period of the Final EIS.

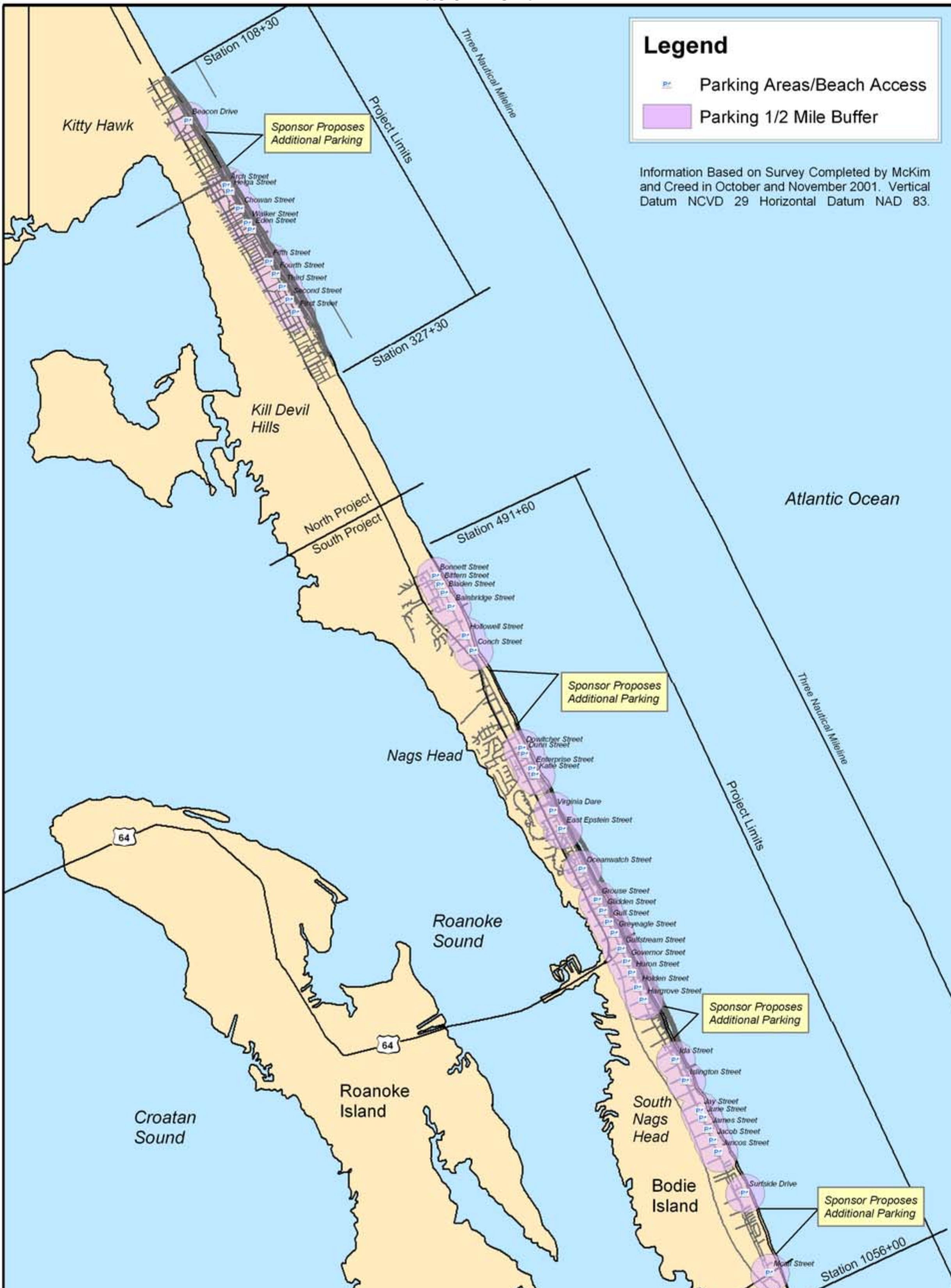
The purpose of this meeting is to advise you that Dare County and its municipal partners in this project are all solidly committed to providing abundant public beach access in the project area and even elsewhere along the Dare County oceanfront. Tourism is our principal industry and without public access we would not have tourists.

I want to confirm to you and anyone else involved in the review of this project that Dare County understands the importance of adequate public access for the project areas. I understand that there are three areas in Nags Head and one area in Kitty Hawk that need additional public access facilities. This memo will serve as Dare County's acknowledgement of that situation and our agreement to provide the required public access improvements during the PED and construction phase of the project.

I hope this memo conveys our commitment to address the public access issues raised during the comment period and should you need additional information please let me know.

Cc: Terry Wheeler, County Manager

Attachment 4



Dare County Beaches
Bodie Island Portion
Parking Areas with Beach Access
(Showing 1/2 Mile Buffer from Center of Parking Lot)

N

0 1 2 4 6 8 10 Miles

US Army Corps of Engineers
Wilmington District

Attachment 5

STATEMENT OF WORK

FINAL
MONITORING PLAN

ASSESS POTENTIAL ENVIRONMENTAL IMPACTS
ASSOCIATED WITH THE DARE COUNTY BEACHES (BODIE ISLAND)
SHORELINE PROTECTION PROJECT
DARE COUNTY, NORTH CAROLINA

Prepared for

Frank Yelverton
U.S. Army Corps of Engineers
Wilmington District
P.O. Box 1890
Wilmington, NC 28402-1890

Prepared by

Versar, Inc.
9200 Rumsey Road
Columbia, Maryland 21045

GSA Contract No GS-00F-0007L

Prepared Under the Supervision of

____

William H. Burton
Technical Director

Revised February 2004

Attachment 5

STATEMENT OF WORK
FINAL MONITORING PLAN
ASSESS POTENTIAL ENVIRONMENTAL IMPACTS
ASSOCIATED WITH THE DARE COUNTY BEACHES (BODIE ISLAND)
SHORELINE PROTECTION PROJECT
DARE COUNTY, NORTH CAROLINA

1.0 Introduction

The purpose of this study plan is to describe the environmental monitoring that will be performed in order to assess the biological impacts of the Dare County beach replenishment project at both the sand borrow sites and at the beaches being restored. Initial construction will entail placement of approximately 8,000,000 cubic yards of sand in the South Project Area, and 4,300,000 cubic yards in the North Project Area, for a total volume of 12,300,000 cubic yards. Initial construction is scheduled to begin in late calendar year (CY) 2005 for both the North Project Area, and the middle segment of the South Project Area. The remaining two phases for initial construction of the South Project Area will begin in late CY 2006 for the southern segment and in late CY 2007 for the northern segment. Beach fill material for the North and South Project Areas will be excavated from the N1/N2 and S1 borrows site located about a mile offshore of Kill Devil Hills and Nags Head, NC, respectively (Figure 1).

Versar Inc. was awarded a contract from the Wilmington District of the U.S. Army Corps of Engineers to develop a monitoring plan based on their overall experience in rigorous statistical design of natural resources surveys and ecological monitoring programs, and, in particular, their recent experience in monitoring a very similar beach replenishment project in Brunswick County study (conducted as part of the Cape Fear River Deepening). After the July 17, 2003 award of the contract, an initial meeting with agency personnel, community planners, environmental groups, and concerned citizens was convened in Kill Devil Hills on August 12, 2003. Approximately 15 people attended the meeting and participated in a site visit to the project area. The attendees were encouraged to voice any particular concerns they may have about the project and to comment on what issues should be addressed in the monitoring plan. Because the plan was in the initial stages of development at the time, only a broad outline of potential monitoring program elements and a sampling schedule were discussed at that meeting. The draft monitoring plan was sent to all attendees at the meeting and other interested parties who were invited to submit format comments by December 19, 2003. Responses to comments are summarized in Appendix A. This monitoring plan has been revised based on comments received.

The USACE made it clear that they would conduct two years of pre-construction monitoring (to establish a baseline), one year of direct impact monitoring, and at least two years of post-construction monitoring (to assess recovery). Because the construction schedule calls for beach replenishment to commence in late CY 2005 at the North Project Area (Figure 1), this beach and associated borrow sites was selected for monitoring. The South Project area will not be monitored because

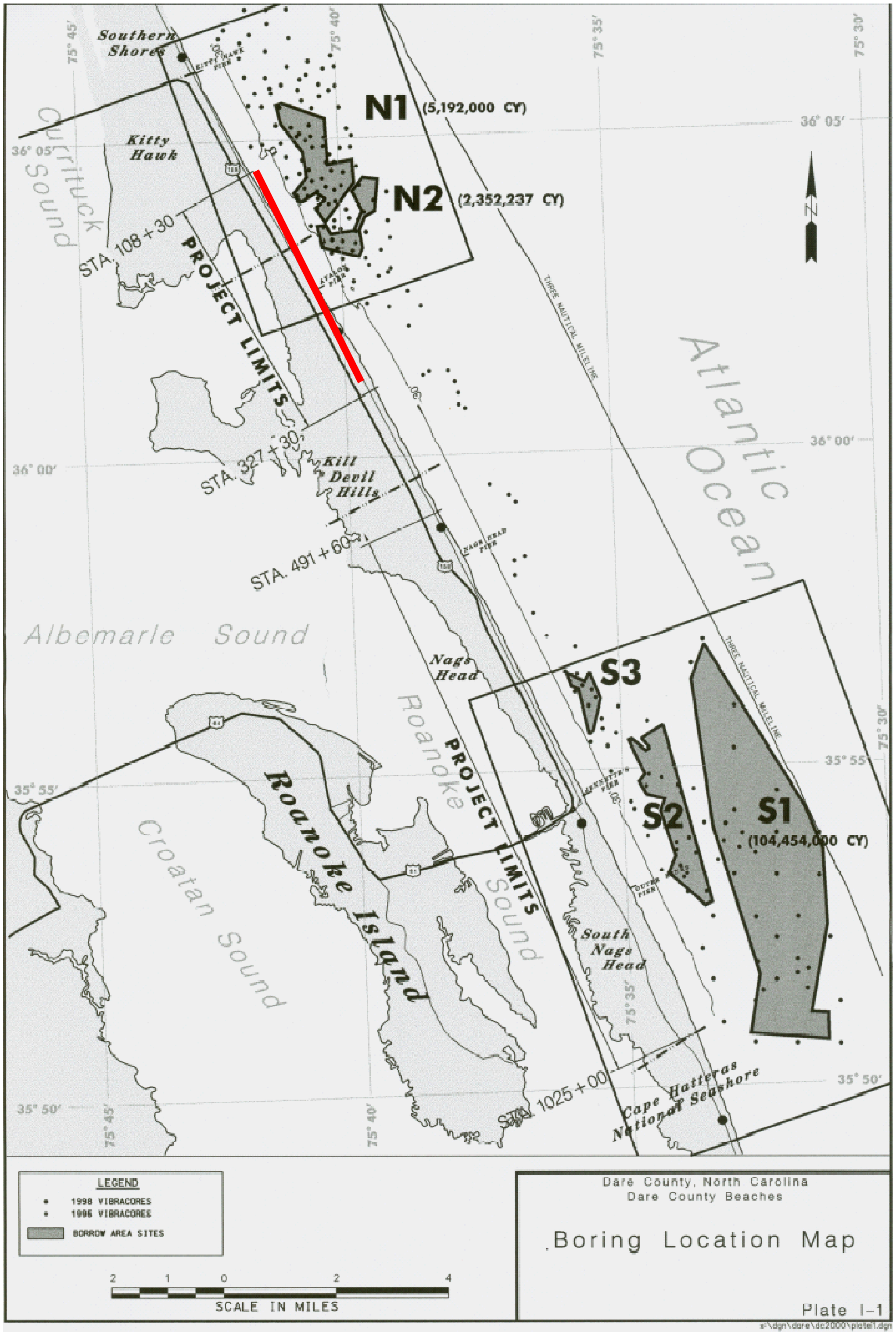


Figure 1. Locations of the North and South Project area and their respective borrow sites for the Dare County beach replenishment project. Red line indicates the approximate location of subject beach study area in the North Project Area. The reference site for the beach sampling is depicted in Figure 2.

there are few physical differences among the beach project area. Thus, the monitoring results at the Northern Project Area will be adequately representative of responses that would occur throughout the entire project area.

This draft monitoring plan consists of four major elements including:

- Pre-construction, during construction, and post-construction monitoring of the project's effects on surf-zone benthic and fish communities (beach studies)
- Pre-excavation, during excavation, and post excavation monitoring of the project's effects on borrow site benthic and fish communities (off-shore studies)
- Weekly shorebird monitoring on the subject and reference beach
- Weekly recreational fishing surveys on the subject and reference beach

2.0 Study Plan

2.1 Beach Effects and Recovery

2.1.1 Pre- and Post-construction Beach Monitoring

Seasonal sampling (i.e., winter, spring, summer, fall) based on a stringent experimental design will be conducted at a series of ten (10) dune to surf zone transects systematically located along the length of the North Project Area (Figure 1) and at ten (10) transects along a reference beach (Figure 2) two years prior to construction and two years after construction (Table 1). The beach will be divided into ten longitudinal segments, with transects randomly positioned at within each segment. The transects will coincide with the physical monitoring transects (conducted by another contractor) and will remained fixed for the duration of the program. The locations of the transects will be fixed for the length of the study to strengthen the ability to detect temporal changes in abundance, biomass and population characteristics resulting from the beach replenishment. Fixed transects over time will reduce the effects of spatial variability, thus enhancing the power for detecting temporal changes. Seasonal sampling will be conducted within a two-week window and confined to similar temporal periods, water temperatures, and weather conditions to the extent that project logistics allow.

The reference beach will be located in a similar surf-zone beach habitat north of the replenishment project near the USACE Coastal and Hydraulic Laboratory facility in Duck, NC. All benthic and fish parameters measured at the subject beaches will also be measured at ten systematically allocated transects established at the reference for each seasonal sampling event. The reference beach will be similar in length to the subject beach (3 miles) with transects spaced randomly within ten segments.

Table 1. Generalized monitoring schedule for the North Project Area for the Dare County beach replenishment project.				
2004	2005	2006	2007	2008
Pre-construction	Pre-construction	During Construction	Post-construction	Post-construction

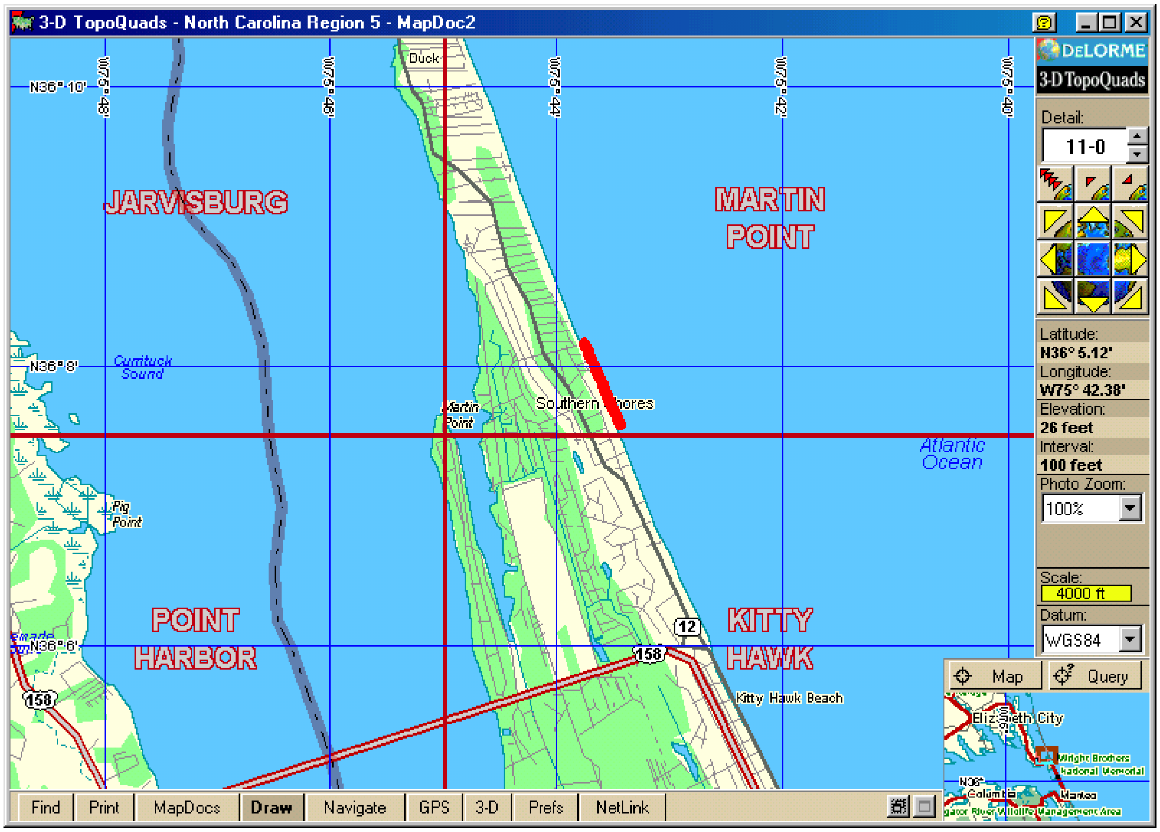


Figure 2. Location of reference beach north of Kitty Hawk, NC (site near the USACE Field Research Facility)

Benthic Sampling

Benthic invertebrate species composition, abundance, and biomass will be quantified by collecting bottom grab samples in swash zone and shallow sub-tidal habitats. The shallow sub-tidal habitat is defined at that area below the low tide line in about 2 feet of water. No sampling in the deep habitat (the zone just outside the breaking waves in about 12 feet of water) is proposed. Studies conducted on the Brunswick County beaches indicated that this habitat was marginally affected by beach replenishment activities (Versar 2002 and 2003) making the additional effort for monitoring this habitat unjustified. One sample will be collected in each habitat at each of the ten transects on the subject beach. Similarly, one sample per habitat will be collected at each of the ten transects at the reference beach for each seasonal event. Replicate samples at each sampling point along the ten transects is not recommended as we are interested in characterizing the conditions along the entire length of the subject beach, not at one particular spot. For the Brunswick study we collected two replicate samples in each habitat along eight transects. Analysis of the replicate samples indicated that the observations from the samples taken in one small area were more similar than observations from different transects. For this study we used an intra-cluster correlation coefficient (Snedechor and Cochran 1980) to measure the homogeneity of samples taken near each other relative to samples among transects. The results indicated that we would have been much better off if we had spread our sampling points out along the beach rather than taking multiple samples at one point.

To determine the appropriate number of samples we used a proportional odds model (Agresti 1990) to compute the power of detecting shifts in the distribution of abundance or biomass data collected before and after impact using the Brunswick County data. In principle, data on abundance or biomass collected before impact can be grouped into four ordered categories, from low to high abundance levels, based on the quartiles. Using this approach, the null hypothesis for a test then can be that the distributions of samples by abundance category are the same before and after impact (25% in each). The alternative hypothesis could specify that the samples collected after impact has a distribution of values that is shifted towards lower abundance categories. We used a proportional odds ratio of two for the alternative hypothesis (i.e., the impacted samples would be twice as likely as the before samples to be in a lower category), corresponding to 71% of samples being in the low abundance category and only 4% being in the highest abundance category. Using Proc-StatXact we estimated that ten samples per habitat will provide a power of over 80% to detect a shift in abundance or biomass for benthic communities (Table 2) of at least this magnitude for an alpha level of 10%. This is a reasonable balance of type I and type II errors.

Table 2. Power for detecting a shift in distribution of abundance and biomass data, with before impact samples having equal distributions, and the after impact samples showing a shift towards lower values with proportional odds ratio of 2.0.		
	Alpha-level	
Sample size per habitat (n)	**5%**	**10%**
5	31	50
6	42	62
7	50	67
8	58	73
9	65	78
10	70	82

Swash zone and shallow subtidal samples will be collected at or near low tide from the beach by wading out into the surf-zone approximately 30-feet from the low tide line with a handheld ponar grab. The ponar grab will be worked into the sediment by stepping on the top of the grab in shallow water so that the depth of sample will be 10-cm. All samples will be sieved through a 0.5mm screen and all retained organisms will be identified to species (or lowest practical taxon) and counted for both the swash and shallow subtidal samples. After identification and enumeration, organisms will be grouped into predetermined taxonomic levels for ash-free dry weight (AFDW) biomass determinations. AFDW biomass will be determined by (1) drying and weighing each taxonomic group to a constant weight at 60 °C, (2) ashing in a muffle furnace at 500 °C for 5 hours, and (3) weighing the remains. For each seasonal event at the subject beach and the reference beach, a combined total of 40 benthic samples will be collected, yielding 160 benthic samples per year (Table 3).

Area counts of ghost crab holes shoreward of each sampling transect will be conducted during each sampling event. While the ghost crab hole data collected in the Brunswick county study were of limited value, the minimal time it takes to collect this information warrants its inclusion in the program. Two 30-foot long transects parallel to shore will be marked on wrack line of the beach and all ghost crabs holes behind each transect extending to the toe of the dune will be recorded. To provide replicate counts within each 30-foot section each swash zone to dune toe ghost crab borrow count sequestered into five six-foot wide “counting” lanes. The distance from the wrack line to the dune toe will be noted to provide a ghost crab density estimate for each sampling area. One ghost grab will be assumed to occupy each active hole.

Sediment samples for grain size analysis will be taken at the ten swash and ten shallow samples for both the subject beach and reference beach. Grain size will be measured using ASTM Method D2487. Sieve sizes will range from 4.75 mm (U.S. Standard Sieve No. 4) to 63 micron (U.S. Standard Sieve No. 230). The primary purpose of the grain size analysis is to provide ancillary qualitative information on sediment conditions to help interpret the benthic invertebrate results. To provide information on changes in shell distribution that may affect foraging shore birds large shells will be counted as well. The grain size samples will be collected directly adjacent to the benthic sample grabs using the same gear. The ten samples for each habitat will be composited for both the subject beach and reference beach for a total of 4 grain size samples per season (Table 3). Based on the Brunswick County work grain size distribution within the swash and shallow habitats were very similar so composite samples between the subject beach and reference beach should be adequate to help discern benthic community parameter differences that are related to grain size. Because sediment characteristics can influence benthic community composition, these data can be used partition project impacts from natural variation due to sediment effects.

Haul Seine Sampling

Commercial haul seine collections will be conducted in the proximity of each of the ten subject beach transects and the ten reference beach transects using a 250 yard haul seine (half the length typically deployed in this local fishery). Use of half the length of the commercial seine is advantageous because it can be deployed and retrieved more rapidly, thereby increasing the number of hauls that can be taken for a fixed survey cost. Also, deploying the entire length of haul seine (500 yards) would sample too large an area (i.e., bottom habitats not impacted by the beach replenishment). The haul seine will be deployed in a semi circle so that an approximate sampling radius of 125 yards will be swept for each sample. Seine mesh size will be 3-inch stretch and will target larger recreationally and commercially important species. This effort is expected to take about four field days per season as the local commercial fishermen that will be contracted to conduct the hauls estimate that each sample will take about two hours to deploy, retrieve, and work up the catch. Beach seining will be restricted to relatively calm conditions (wave height of 2-feet or less). Each seasonal haul seine sample will be collected in conjunction with one sample at the ten reference site transects near Duck, NC. Versar fisheries biologists will accompany the commercial haul seiners to direct and assist with the sampling effort and record the catch data. Sampling at or near low tide is recommended to control for possible differences if fish abundance among various tidal stages and to provide an area to work on the eroded beaches. Fishes and macroinvertebrates (e.g., crabs and shrimps) will be identified to species and enumerated. A random sample of 25 specimens for each species will be measured for total length for each seine haul.

Three target species of demersal feeding adults fish taken from the haul seine samples will be retained for gut content analysis. Fish species with demersal feeding habitats that are closely linked to the benthic invertebrates that will be directly impacted by the beach re-nourishment will be selected. Anticipate target species include gulf kingfish, spot, spotted hake, Florida pompano, black drum, or Atlantic croaker. Seasonal changes in fish composition may require that we use more than three target species over the course of a year. These data will be used to estimate prey selectivity by fishes and evaluate feeding responses of fishes to changes in densities of invertebrate prey species caused by the beach construction. The stomach of fish from specimens selected for gut content analysis will be dissected upon collection and immediately frozen on dry ice or in a portable freezer to prevent the digestion of soft-bodied organisms. Gut content analysis will include identification to the lowest practical taxon, and frequency of occurrence of each taxa. For the entire gut contents the percent full, total dry-weight biomass of prey items found in the stomachs will be measured. The sampling of stomachs for each species will be stratified by size class, with two stomachs collected from each length class. The analysis of stomachs collected for each target species will be spread out across stations, and over time. Initially a minimum of 5 stomachs will be analyzed for each target species from any individual catch. Because intra-haul correlation is expected for prey items, little loss in precision is expected to result from this subsampling as compared to sampling all stomachs (Pennington and Vølstad 1994a, 1994b; Bogstad et al. 1995).

Table 3 presents a summary of the proposed sampling effort for each year of the pre- and post-construction monitoring effort on the subject and reference beach.

Table 3. Summary of proposed sampling effort each year of the pre- and post construction monitoring for the subject and reference beaches.

	Winter	**Spring**	**Summer**	**Fall**
Subject Beach				
Ghost Crab Transects	**20**	**20**	**20**	**20**
Benthic - Swash	**10**	**10**	**10**	**10**
Benthic - Shallow	**10**	**10**	**10**	**10**
Grain Size (swash and shallow)	**2**	**2**	**2**	**2**
Haul Seine - Fish	**10**	**10**	**10**	**10**
Reference Beach				
Ghost Crab Transects	**20**	**20**	**20**	**20**
Benthic - Swash	**10**	**10**	**10**	**10**
Benthic - Shallow	**10**	**10**	**10**	**10**
Grain Size (swash and shallow)	**2**	**2**	**2**	**2**
Haul Seine - Fish	**10**	**10**	**10**	**10**

2.1.2 During Construction Beach Monitoring

As the beach construction moves through the North Project area, seasonal sampling will be conducted behind and in front of the pipeline using an experimental design that is effective for assessing short-term recovery. Four transects will be positioned near the beach replenishment operations. Three transects will be positioned behind the end of the pipeline to correspond to sections of the beach that were replenished at fixed time intervals representing 2, 4, and 8 weeks of recovery prior to the sampling event (Figure 3). To assess conditions prior to construction during each seasonal event, one transect will be placed in front of the pipeline, in close proximity to the pipeline but with sufficient distance to avoid any down drift effects from the beach re-nourishment. Short-term recovery for each season will be assessed from data collected on one sampling event per season. The exact location of each transect will be repositioned each season according to the progression of the beach replenishment, which will be carefully monitored throughout the construction period. The primary advantage of this design is that samples are collected simultaneously in sections of the beach that are in various recovery states, thus removing the influence of natural temporal variation in the abundance, biomass, and composition of benthic communities that could mask effects of the replenishment. The proposed design will provide estimates of average abundance (biomass) at 2, 4, and 8 week recovery periods and for sites in front of the pipe (control) across seasons and space. Thus, there is a spatial/temporal replication incorporated into the design. Although, spatial and temporal patterns cannot be separated, the study should provide estimates of average abundance (biomass) for each recovery period. If the pre-construction sampling indicates strong spatial patterns along the alternative designs for estimating short-term impacts will be considered. One possible approach is to sample one or more small areas in front of the pipe, and then re-sample these areas after 2,4, and 8 weeks of recovery time has passed.

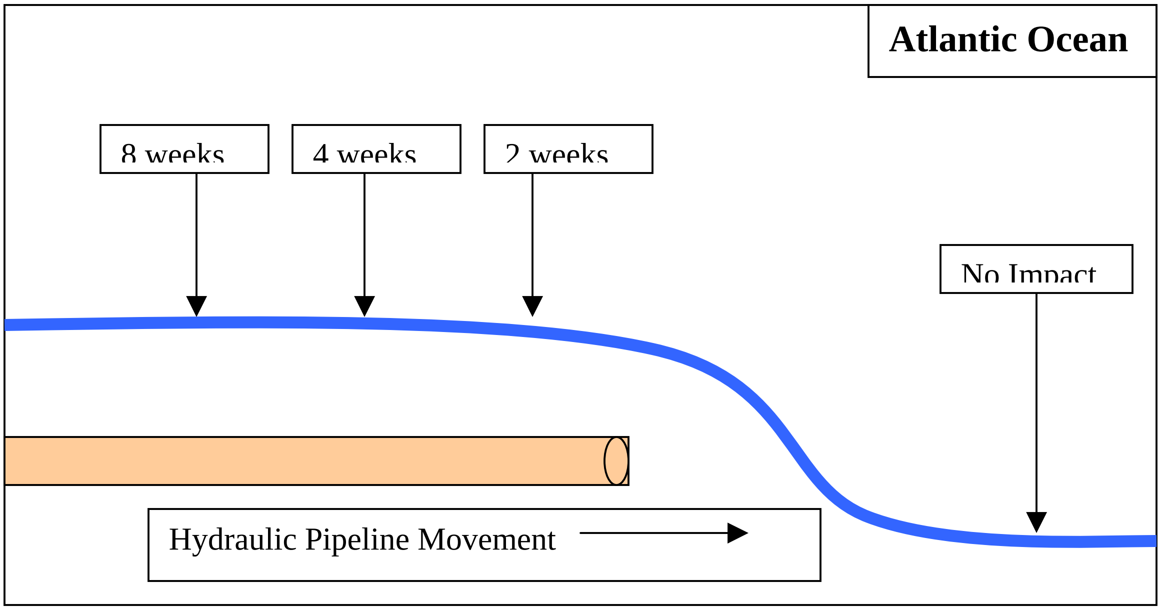


Figure 3. Schematic of during construction seasonal sampling at three recovering and one non-impacted transect on the subject beach.

Benthic Sampling

For each seasonal during-construction event, five replicate samples will be taken within each habitat (swash and shallow) at the four transects, for a total of twenty (20) samples per habitat (Table 4). Because we are interested in short-term differences related to recovery from the beach replenishment, replicate sampling at each specific site is needed to differentiate between small scale spatial variation and parameter differences related to various recovery time periods. Along with the subject beach sampling, one sample per habitat will be taken at each of the ten reference site transects. One composite sediment sample will be collected at each habitat along the four subject beach transects for grain size analysis, for a total of eight (8) samples (Table 4). Two composite grain size samples will be collected among the ten transects at the reference beach (swash and shallow) for a total of 10 samples for each construction season collection event. Ghost crab hole counts behind each transect will also be conducted following the protocols established for the pre- and post-construction monitoring.

Haul Seine Sampling

For each seasonal event, replicate hauls seine will be conducted behind and in front of the pipeline in proximity to the areas established for the benthic sampling. The four stations will be sampled on two consecutive days to provide two replicate samples for each transect (due to the large size, anticipated large catches and the complicated nature of haul seining, only about 4 to 5 haul seines can be accomplished in a day). Sampling at or near low tide is recommended to control for possible differences if fish abundance among various tidal stages and to provide an area to work on the eroded beaches.

Three target species of demersal feeding adults fish taken from the haul seine samples will be retained for gut content analysis. Gut content analysis will include identification to the lowest practical taxon, and frequency of occurrence of each taxa. For the entire gut contents the percent full, total dry-weight biomass of prey items found in the stomachs will be measured. The sampling of stomachs for each species will be stratified by size class, with two stomachs collected from each length class. The analysis of stomachs collected for each target species will be spread out across stations, and over time. Initially a minimum of 5 stomachs will be analyzed for each target species from any individual catch.

Table 4 presents a summary of the proposed sampling effort for the construction year monitoring effort on the subject and reference beach.

Table 4. Summary of proposed sampling effort during the construction year monitoring for the subject and reference beaches.

	Winter	**Spring**	**Summer**	**Fall**
Subject Beach				
Ghost Crab Transects	**8**	**8**	**8**	**8**
Benthic - Swash	**20**	**20**	**20**	**20**
Benthic - Shallow	**20**	**20**	**20**	**20**
Grain Size (swash and shallow)	**8**	**8**	**8**	**8**
Haul Seine - Fish	**8**	**8**	**8**	**8**
Reference Beach				
Ghost Crab Transects	**20**	**20**	**20**	**20**
Benthic - Swash	**10**	**10**	**10**	**10**
Benthic - Shallow	**10**	**10**	**10**	**10**
Grain Size (swash and shallow)	**2**	**2**	**2**	**2**
Haul Seine - Fish	**10**	**10**	**10**	**10**

2.2 Borrow Area Effects and Recovery (Borrow Area N1/N2)

2.2.1 Pre- and Post-construction Borrow Area Monitoring

To assess the long-term ecological effects and recovery from the sand excavation at the offshore borrow site, seasonal sampling of benthic invertebrates and fish communities and remote bottom imaging is proposed. The area within borrow site N1/N2 that will be used as a source of sand for the North Project Area will be delineated based on consultant with the USACE and the dredging contractor. The borrow area reference will be selected based on the result of a bottom imaging survey to be conducted prior to initiating the program. To verify that the selected off-shore reference site posses similar physical and biological characteristics to the borrow site a two-day bottom imaging survey (see below) will be conducted at the beginning of the program at Borrow Site N1/N2, Borrow Site S1 (to verify similar surface conditions exist relative to N1/N2), and potential areas around North Project Area and South Project Area borrow sites in state waters. Based on these data the reference site will be selected such that the physical and biological features are similar to those observed at Borrow Area N1/N2. To avoid any disturbance of the study area during the seasonal sampling the benthic collections will be done first, followed by the bottom imaging, and finally the trawl survey to the extent that is logistically feasible.

<u>Benthic Sampling</u>

Seasonal benthic surveys of invertebrate abundance, species composition, and biomass will be conducted at the borrow site and its respective reference site. For each seasonal sampling event ten (10) borrow area and ten (10) reference site samples will be collected (Table 5). Based on our power analysis of the Brunswick County sampling we anticipate a power of 0.80 to detect differences. Grabs will be taken using a Young grab deployed from Versar’s sampling vessel. Any grabs that penetrate less than 7-cm of sediment will be rejected and re-sampled. Each benthic invertebrate sample will be accompanied by a grain size sample (i.e., not composited) because sediment characteristics can influence benthic community composition, particularly in this deeper habitat that is expected to have a higher variation in sand and slit content relative to surf-zone habitats. These data will help partition project impacts from natural variation due to sediment effects.

<u>Bottom Imaging</u>

To characterize large epi-benthic fauna and macro-scale physical features within the borrow site and reference site a late summer bottom imaging survey will be conducted in the two pre-construction and the two post-construction years of the project. The bottom imaging will be accomplished using an epi-benthic sled equipped with an underwater camera and light strobe, with tracks allocated to provide representative samples from the study area. The bottom imaging will be done along established tow lanes that will be consistently re-sampled in subsequent years. Thousands of geo-referenced images will be recorded over the subject borrow site and reference site. Images will be postprocessed in the laboratory where both physical and biological bottom features will be examined and categorized. The physical and biological categories will provide information on relative complexity of the bottom habitat and will help evaluate changes in the habitat caused by dredging operations. Bottom imaging will be conducted over a two-day sampling effort before the seasonal trawl sampling to avoid altering the habitat by the trawl gear (one day each for the Borrow Site and reference site).

The towed sled (Figure 4) will have three video cameras mounted in three different configurations to provide a broad overview of: 1) the bottom water column and cables leading to the surface, 2) near bottom horizontal view to see fish over the bottom and bed form types, and 3) a vertical high resolution view for sediment type and biogenic features. The broad overview camera will be mounted about 1.5 feet off the bottom and angled to view the bottom out in front of the sled from 6 to 30 feet. The near bottom horizontal camera will be mounted 1.2 feet off the bottom at an oblique angle of 20^{o} to provide a close-up view of bottom morphology and the presence of juvenile fish and other mobile fauna from 1.2 to 3 feet in front of the sled. The vertical camera will be mounted perpendicular to the bottom of the sediment surface. Illumination for the vertical and horizontal cameras will be provided by electronic video strobes. The video sled will be linked to the surface via two cables that provided power to the cameras and strobes. The video signals will be transmitted to the surface where sled performance and bottom features can be viewed in real-time. The video signal from each camera will be multiplexed and recorded on to a single master tape that will be used for aligning the video from the horizontal and vertical cameras. Video signals from the horizontal and vertical cameras will also recorded on higher resolution digital recorders for later analysis. Video data files for each region of interest and reference site will be combined with the DGPS positions by aligning timing mark placed in the DGPS files, the time code recorded with the multiplex video, and the time code generated by the digital video recorders used with the horizontal and vertical cameras.

Benthic habitats will be classified by analyzing videotapes recorded from the horizontal and vertical cameras. Physical and biological features will be sampled from the recorded videotape at 2.5-minute intervals. All fish visible from the forward or downward cameras will be identified to the lowest possible taxon and physical and biological features of the benthic habitats at the instance the fish was will be recorded. Data on bed roughness, sediment type, shell hash, biogenic structures, epifaunal organisms, and fishes and rays will be collected and entered into an excel spreadsheet

Bottom habitats will be classified based on both physical and biological characteristics. Physical characteristics will include variables for bedforms type and size, which are primarily wavelength and form, and sediment grain size. Biological characteristics included variables for shell fragment cover, mobile fauna, sedentary fauna, and other biogenic structures (Figure 5). Maps of the various biological and physical bottom features will be made using GIS software for each seasonal survey similar to the map presented in Figure 6.

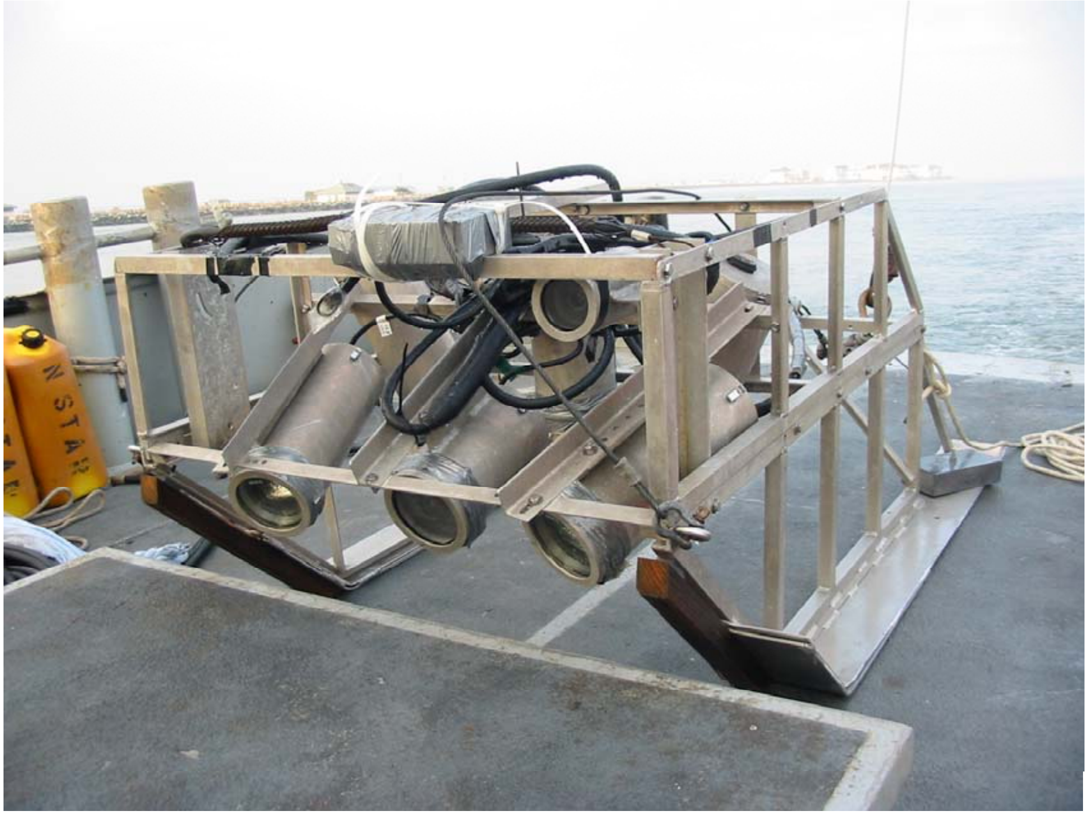


Figure 4. Video sled to be used to conduct bottom imaging surveys within Borrow Site N1/N2 and the selected reference site. The overview camera is at the top right corner of the sled, horizontal camera is in the front center and flanked by two electronic video strobes, close-up vertical camera is in the center of the sled, behind the horizontal camera.

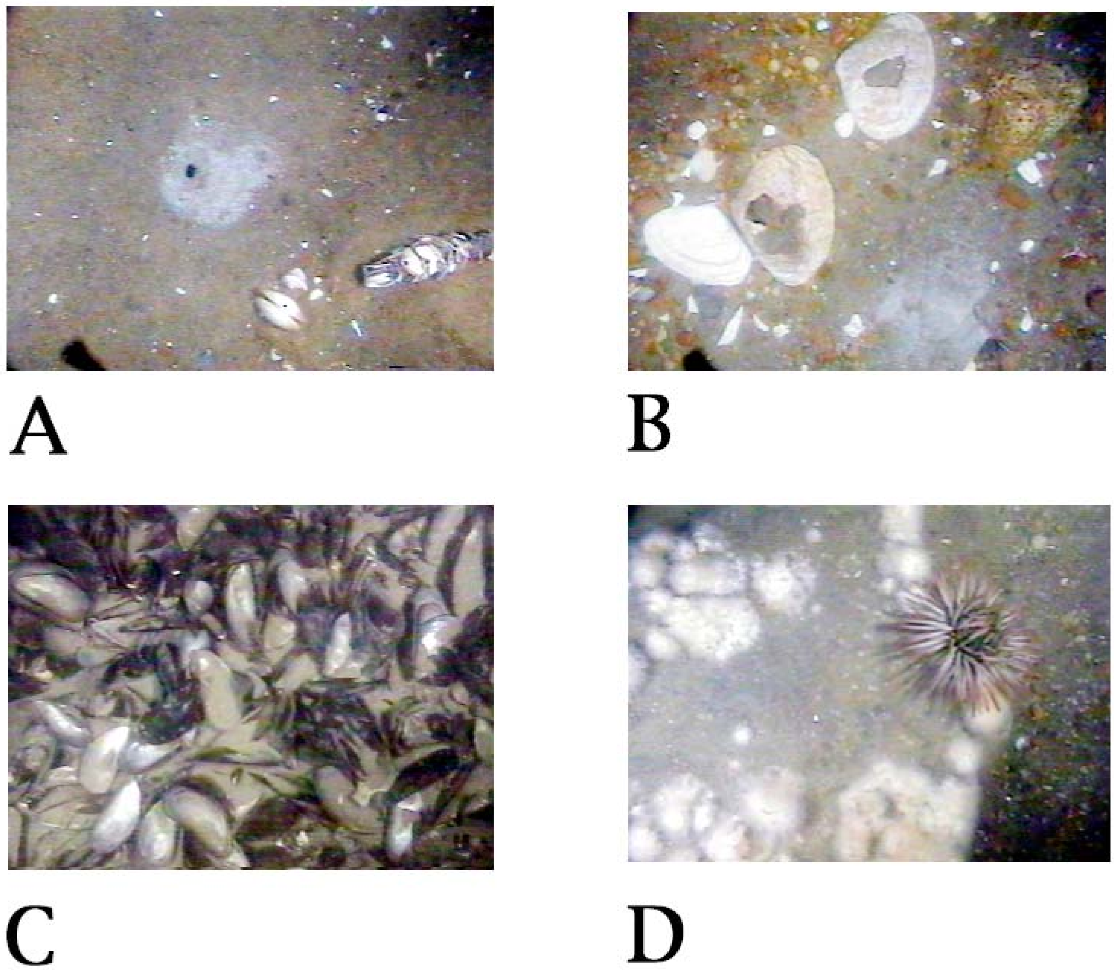


Figure 5. Examples Biological Habitat types observed in video sled survey studies: A - Biogenic feeding mound produced by subsurface feeding organisms; B – Surf clam shell bed; C – Blue mussel shell bed; D – Encrusting bryozoans on cobble. Each image is 28 cm wide.

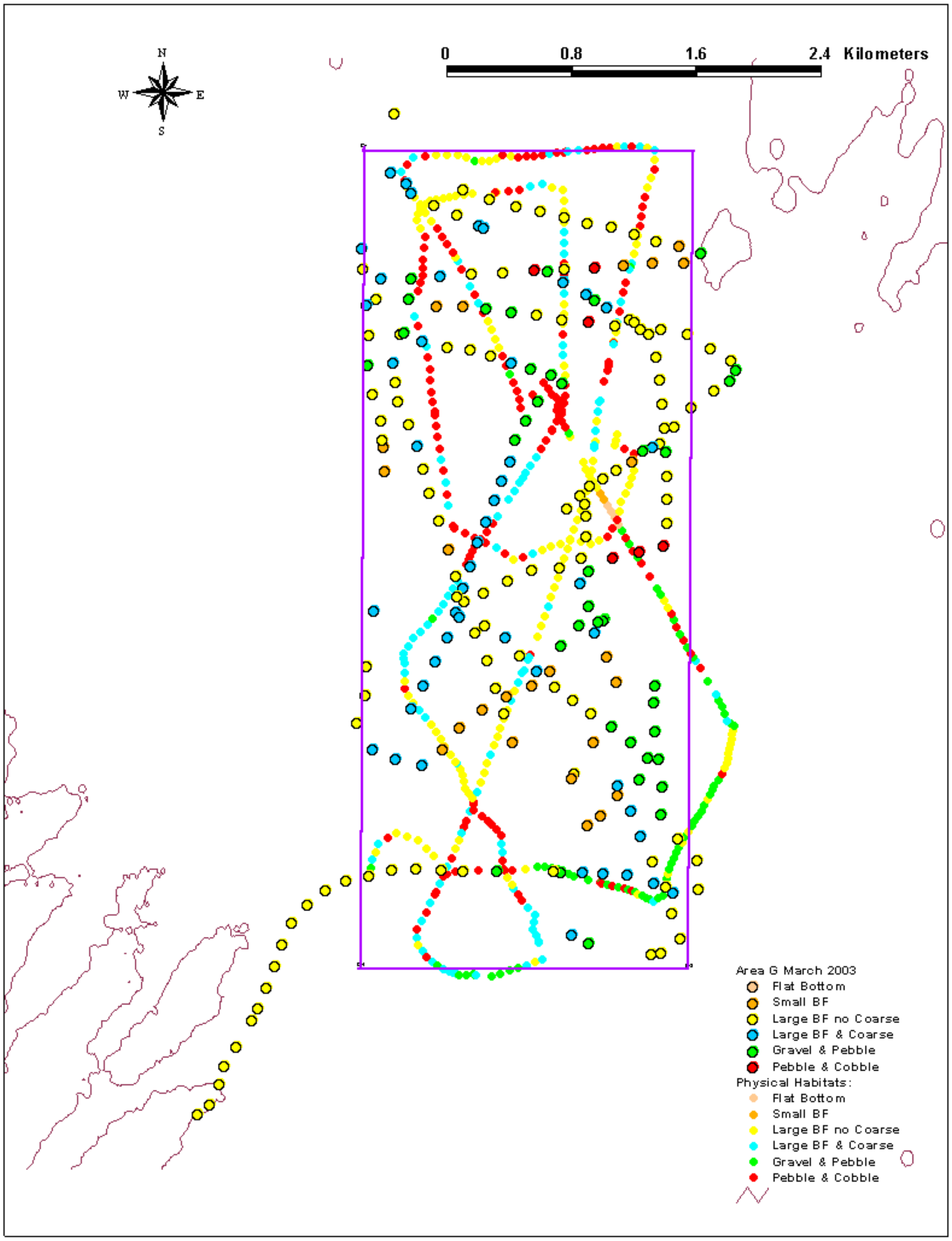


Figure 5. Example of video mapping data display showing various physical bottom features observed within the sled track lines.

Commercial Trawl Sampling

Seasonal collections of fish and shellfish abundance and species composition will be conducted in the borrow site and reference site. Fish collections will be conducted using a local commercial trawler (hired out of Oregon Inlet or other nearby port) equipped with 80-foot otter trawls outfitted with a small (removable) mesh liner in the cod-end to retain juveniles as well as adults. Versar fisheries biologists will be onboard the vessel to direct the sampling activities, assist with the gear, and work up the data on the trawl catches. The experience of the captain and his crew will be employed to maximize the effectiveness of the gear. Trawling will be restricted to relatively clam seas (i.e., wave heights greater that 4-feet). One standardized trawl haul will be conducted at each of twelve representatively selected locations within the borrow site and the reference site, for a total of 24 swept-area samples per season (Table 5). Sampling sites will initially be selected based on a stratified random approach, and then fixed for all subsequent surveys to reduce spatial variability and enhance the ability to detect trends. To avoid trawling over the same area twice in one year subsequent transects will be offset by a few hundred feet for each of the four seasons. Trawls will be towed at constant speed for 5 to 10 minutes depending on the season fish densities and the advise of the vessel's captain who will be contracted to conduct the trawls. Distance covered will be estimated from Differential Global Positioning System (DGPS) coordinates recorded at the beginning and end of each trawl. Collected fishes and macroinvertebrates (crabs and shrimps) will be identified to species, enumerated, and a random sample of 25 specimens for each species will be measured for total length for each trawl.

Three target species of demersal feeding adults fish taken from borrow and reference site trawl samples will be retained for gut content analysis. These data will be used to estimate prey selectivity by fishes and evaluate feeding responses of fishes to changes in densities of invertebrate prey species caused by the sand excavation. Gut content analysis will include identification to the lowest practical taxon, and frequency of occurrence of each taxa. For each stomach, the percent fullness and total dry-weight biomass of prey items for the entire gut content will be measured. The sampling of stomachs for each species will be stratified by size class, with two stomachs collected from each length class chosen to represent year classes. The analysis of stomachs collected for each target species will be spread out across stations, and over time. Initially a minimum of 5 stomachs will be analyzed for each target species from any individual catch.

Table 5 presents a summary of the proposed sampling effort for the pre- and post-construction year monitoring effort at Borrow Site N1/N2 and offshore reference site.

Table 5. Summary of proposed sampling effort during the pre- and post construction year monitoring for Borrow Sites N1/N2 and offshore reference site.

	Winter	**Spring**	**Summer**	**Fall**
Borrow Site N1/N2				
Benthic – Young grab	**10**	**10**	**10**	**10**
Grain Size	**10**	**10**	**10**	**10**
Commercial Trawl - Fish	**12**	**12**	**12**	**12**
Bottom Imaging (days)	**0**	**0**	**1**	**0**
Borrow Site Reference				
Benthic – Young grab	**10**	**10**	**10**	**10**
Grain Size	**10**	**10**	**10**	**10**
Commercial Trawl - Fish	**12**	**12**	**12**	**12**
Bottom Imaging (days)	**0**	**0**	**1**	**0**

2.2.2 During Construction Borrow area Monitoring

Borrow Area N1/N2 will be partitioned into four equally spaced sections for seasonal sampling. Since it is anticipated that the excavation will take the better part of a year and will be done primarily by a pipeline dredge, seasonal effects will be limited to specific areas within the borrow site. Sampling four separate strata can partition the data partitioned into various recovery time frames. The construction contractor will supply the environmental contractor with a tentative schedule of where and when they plan to dredge. This information will be updated and mapped as they progress in case deviations in the dredging schedule occur that may require adjustments in the biological sample locations. For each seasonal sampling event during the sand excavation operation benthic and fish sampling will be conducted in the strata being impacted and the three strata not being impacted by the excavation operation. Data analysis will include comparing the benthic and fish communities in the reference borrow area to the various stages of impact and recovery strata sampled within the active borrow site sampled throughout the construction season.

Benthic Sampling

Ten benthic samples will be collected in each of the four borrow site strata during each seasonal event. Ten benthic samples will also be collected in the borrow site reference site for a total of 50 benthic samples per season (Table 6 and 7). Each benthic invertebrate sample will be accompanied by a grain size sample. Subsequent season sampling during the construction year will sample the borrow site strata in various stages of recovery as the dredging equipment moves through the area (Table 6).

Table 6. During construction borrow site sampling plan for benthic invertebrates. The number of replicate samples is indicated within the cells of the table.

Season 1	**Season 2**	**Season 3**	**Season 4**
Borrow Area			
10	**10**	**10**	**10**
10	**10**	**10**	**10**
10	**10**	**10**	**10**
10	**10**	**10**	**10**
Key:			
IMPACTED	**NOT IMPACTED**	**RECOVERY**	
Reference Site			
10	**10**	**10**	**10**

Bottom Imaging

To characterize potential changes to large epi-benthic fauna and macro-scale physical features within the borrow site a late summer bottom imaging survey will be conducted during the construction year. This survey will be used to assess the effects of the excavation in the segments recently mined and to the areas not disturbed by the dredge. The bottom imaging will provide data on how the dredging altered the bottom features and will include reference site bottom imaging.

Commercial Trawl Sampling

Three trawls each of the four strata will be collected each season within the construction year (total of 12 tows per season; Table 7). In conjunction with the borrow site collections twelve (12) samples will be conducted in each survey season at the reference borrow site area established for the benthic sampling. Stomach content analysis will be conducted on the target species as per the pre- and post-construction monitoring. The data analysis for the during construction trawl collections will be similar to the analyses conducted for the pre- and post construction monitoring periods.

Table 7 presents a summary of the proposed sampling effort for the construction year monitoring at Borrow Site N1/N2 and offshore reference site.

Table 7. Summary of proposed sampling effort during the construction year monitoring for Borrow Site N1/N2 and offshore reference site.

	Winter	**Spring**	**Summer**	**Fall**
Borrow Site N1/N2				
Benthic – Young grab	**40**	**40**	**40**	**40**
Grain Size	**40**	**40**	**40**	**40**
Commercial Trawl - Fish	**12**	**12**	**12**	**12**
Bottom Imaging (days)	**0**	**0**	**1**	**0**
Borrow Site Reference				
Benthic – Young grab	**10**	**10**	**10**	**10**
Grain Size	**10**	**10**	**10**	**10**
Commercial Trawl - Fish	**12**	**12**	**12**	**12**
Bottom Imaging (days)	**0**	**0**	**1**	**0**

2.3 Bird Counts

Shorebird counts (including piping plovers) will be conducted during the pre-, during, and post-construction periods along the entire 3-mile length of subject beach and reference beach in Duck, NC. Counts will be conducted weekly from February 15 through November, and every other week in December and January following the field methods used for the Brunswick County study (CZR 2003). This effort will be coordinated with local environmental groups and will involve a local hire to conduct this work under Versar's supervision. While conducting this survey the field technician will take field notes estimating the number and species of the shorebirds feeding, nesting, or loafing along the length of beach. The observer will take bird observations while walking in a linear or zigzag fashion (depending on the width of the beach). The field data will be stratified by 1000-foot beach sections to provide spatial information on bird populations on the subject beach. The field technician will also record the number people using the beach area, whether any local beach construction activities are occurring (e.g., dune building) and other pertinent information such as tide state, wind speed and direction, air temperature. All observations will be taken in the morning hours (during first feeding) and the start day of the week will be randomized to the extent feasible. No surveys will be conducted under high wind conditions (e.g.> 25 mph).

2.4 Recreational Fishing Survey

Recreational fishing surveys will be conducted weekly along the entire 3-mile length of beach (and fishing piers) located on the subject beach and the Duck, NC reference during the pre-, during-, and post-construction periods. This effort will also be coordinated with local environmental groups and will involve a local hire to conduct this work under Versar's supervision. Survey questionnaire forms will include data field similar to those used by local and state natural resources agencies.

Because recreational fishing is likely to occur along the entire stretch of beach it would be costly to conduct an exit survey, with data collection (by interviews) from completed fishing trips. Hence we propose to conduct a roving creel survey (Pollock et al. 1994, Chapter 11), with a progressive count of anglers to estimate effort along the beach. In the roving survey, effort cannot be obtained directly from angler interviews as in the exit survey design because the field technician intercepts the anglers before they complete their fishing trips. We propose to alternate the weekly sampling between weekend days and weekdays. All fishermen interviews will be made during daylight hours and day of the week and time interval will be randomized to the extent possible.

The direction of the count will also be randomized to eliminate bias. The field technician will walk the length of the subject beach and count the number of people (and poles per person) actively fishing along the beach. For the subject and reference beach, the counts will be conducted separately for fishing piers and the remaining stretch of beach within the study area (these represent three strata). This stratification is likely to improve the precision in overall estimates of fishing effort for the subject beach by reducing the variation on angler counts within the designated strata.

Before or after completing the initial count the field technician will interview actively fishing recreational fishermen using pre-printed survey forms. If feasible, the angler counts will also be grouped into categories depending on the number of fishing rods (i.e., number of anglers with one rod, number of anglers with two rods, and so on). The combined count and interview survey on the subject and reference beach is expected to take about two days for each weekly event. Because it will not be possible to interview fishermen at the end of their trip they will be primarily asked what the caught in their last hour of fishing to provide a relative measure potential changes in relative catch. The mean catch per hour for each season can then be combined with the independent effort estimate to obtain an estimate of total catch, following methods described in Pollock et al. (1994). This survey will provide estimates of total angler hours and catch by species. Because the mean trip length can only be crudely estimated from incomplete trips, the number of angler trips cannot be precisely estimated form this survey alone. Anglers can be asked when they started, and when they plan to stop fishing, but such estimates are likely to be unreliable because fishing success and weather can influence trip duration. Number of trips can be estimated if mean trip length can be obtained from other sources.

Fishing pier operators will be contacted and asked to participate in the survey by providing estimates of fishing activity based on their tickets sales.

To insure that the recreational fishing survey is conducted in a consistent manner, creel clerk training and a survey manual will be developed to provide the field technicians specific instructions on how to conduct the survey.

Table 8 presents a summary of the proposed sampling effort for the yearly sampling effort (field days) for the shorebird survey and the recreational fishing survey.

Table 8. Summary of the proposed effort for the yearly sampling (in field days) for the shorebird survey and the recreational fishing survey.

	Winter	**Spring**	**Summer**	**Fall**
Subject Beach				
Shorebird Survey Days	**7**	**12**	**12**	**12**
Creel Survey Days	**12**	**12**	**12**	**12**
Reference Beach				
Shorebird Survey Days	**7**	**12**	**12**	**12**
Creel Survey Days	**12**	**12**	**12**	**12**

3.0 Data Analysis

The monitoring will be used to assess area wide effects and to detect and estimate any longitudinal trends (gradients) in benthic and fish population parameters, using standard statistical methods (e.g., Gilbert 1987). The proposed Before-After sampling design will provide simultaneous impact-control data (Schmitt and Osenberg 1996) for assessing short-term impacts, and will control for recovery time length. Project effects on ecological and environmental elements not specifically monitored by the program (e.g., ichthyoplankton populations, large pelagic fish species, marine mammals, turbidity plumes created by the dredges) will be address by conducting literature reviews and drawing inferences from former studies on beach replenishment impacts.

Long-term beach replenishment and borrow site effects will be assessed using a Before-After-Control-Impact (BACI) approach where the addition of a control beach will allow us to separate effects of the beach replenishment from other natural sources of spatial and temporal variability through analysis of variance. The BACI is a survey design commonly used to determine the impacts of alterations of the environment on biological communities (Greene 1979; Underwood 1991, 1994; Osenberg et al. 1994). The simplest BACI design involves sampling before and after impact in treatment and control areas with measurements in all combinations of time and area. As an example of this approach, assume that two beaches are sampled. One beach is subject to disposal, and a neighboring beach with similar characteristics and the reference beach samples will serve as a control. If both beaches are sampled at the same points in time before and after disposal, impact can be assessed by comparing the before and after samples of the control beach with the before and after samples for the disposal beach. A portion of the fixed sites sampled in the short-term effects survey will provide data that can be analyzed within the BACI framework.

Stewart-Oaten et al. (1986) extended the simple BACI design by pairing surveys at several selected time points before and after impact. In the BACI with paired sampling (BACI P) the control and impacted sites are measured at the same time points, and an analysis of how the difference between the control and impact sites changes over time would reveal if an impact has occurred. In the short-term during-construction effects survey, we use an approach similar to the BACI-P to target sampling in the neighborhood of the hydraulic pipeline at regular time intervals. The short-term effects survey follows the progression of the pipeline, and will provide local estimates of the short-term recovery rates and the acute effects of the dredging operation. The BACI-P survey will be conducted once per sampling period for fish and benthos. At each sampling event a nearby site in front of the pipeline (no replenishment yet) and the ten transects on the reference beach will serve as a control to characterize the local benthic and fish communities before impact. This nearby site beyond the altered beach is expected to provide a good reference condition for measuring impact on the biota because it is subject to the same broad-scale natural physical variation at the time of sampling. The area adjacent to the end of the pipeline represents the acutely impacted beach habitat, and sites after pipeline has passed represent impacted habitats at various recovery times. Accurate data on the progression of the pipeline will be recorded to determine specific recovery times.

The benthic results from the swash, shallow subtidal, and borrow site sampling zone will be analyzed using several measures of biological condition including diversity, abundance, and biomass. Diversity will be measured in several ways including but not limited to number of taxa (i.e., taxa richness), Shannon-Wiener Diversity Index, and the Simpson's Dominance Index. Additional data analysis will include, if appropriate, log transformed plots of mean abundance, non-parametric statistics using species rank or total densities, regression analysis, and analysis of variance techniques. Abundance and biomass will be examined in total and in groupings appropriate to the study objectives.

Software for the Statistical Analysis of Correlated Data (SUDAAN) or another statistical package will be used to obtain descriptive statistics (e.g., mean number of species, biomass, CPUE) for undisturbed and impacted beach sections, and for hypothesis testing. Using SUDAAN standard errors of ratio estimates, means, totals, regression coefficients and other statistics in accordance with the complex sample design will be computed (Shah et al. 1997). The samples for benthos and fish will be used to test the acute and short-term effects of disposal. By comparing biomass, abundance, and diversity of fish and benthos at disturbed and undisturbed (control) sites changes in the recolonization rates will be tested using parametric and non-parametric methods.

The broad-scale sampling at regular intervals provides baseline data that reflects natural spatial and temporal variability in fish and benthic communities. Pre-construction and post-construction seasonal sampling at the ten subject beach and ten reference beach transects two years before and after the disposal is will provide data for evaluating long-term impact. The statistical analysis for this pre- and post-construction sampling will focuses on the detection of long-term impact for the study beach, based on samples collected two years before the impact and after the impact. The analyses of long-term effects will consist of tests of differences among means of various attributes (abundance, biomass, and species richness) of each biological community sampled (e.g., benthic macro-invertebrates in the shallow zone) at disturbed and reference sites before impact and after impact. We will use a two-way analysis of variance (ANOVA) model to evaluate long-term effects of beach replenishment on the benthic and fish communities:

$$y_{ijk} = \mu + B_j + T_k + B_j T_k + \varepsilon_{ijk}$$

where B_j represent the main effect of beach location (disturbed beach versus control beach), T_k represents the main effect of time (before disturbance and after disturbance), and $B_j T_k$ represent the interaction of location and time. The ε_{ijk} represents random error terms assumed to be normally distributed with mean zero and constant variance σ^2. The analysis of benthic abundance and biomass will be based on log-transformed mean counts for each station, with a constant of 1 being added to all observations in cases where zero-observations occurred. The main interest in this analysis will be to test if the interaction terms are significant, and if so, to test weather the mean values were depressed in the years after beach replenishment, as compared to sample before disturbance. The main effects are introduced to account for overall differences among years, and for differences between the control beach and study beach.

The spatial sampling coverage of the benthic study along the subject beach will support resource estimates that will be linked with the bird survey. Depending on the feeding habits of bird species, estimates will be provided for different spatial scales from single or combined blocks in the neighborhood of the bird sites on the subject beach.

4.0 Monthly and Annual Reports

Monthly Status Reports: By the fifth working day of each month, a written letter report will be submitted. This report will summarize the previous month's sampling activities, preliminary results, and important observations. These status reports will also be used to discuss potential problems and solutions related to contract performance or conditions that might affect performance. Monthly status reports must accompany requests for partial payment.

Annual Project Reports: Within 120 days of completion of all work tasks under each contract year, the Contractor shall submit a draft report for review. The report and findings shall be objective and fully substantiated by documentation. The report shall follow the format required by reputable scientific periodicals, including abstract, summary, introduction, methods, results, discussion, conclusions and recommendations, references, and appendices. The appendices will contain tabulations of all physical, biological, and statistical data and a list of all participating technical staff and their respective responsibilities on the project. The report shall contain appropriate summary tables and figures. In addition, the report must include:

(1) Equipment maintenance and data collection procedures, equipment replacement and malfunctions, and problems with lost or questionable data;
(2) Description of monitoring methodology, results and any problems;
(3) Discussion of the results, including apparent difference among sites especially as compared to the control.
(4) Comparison of data and existing literature from the first and subsequent years of monitoring especially related to recovery rates and issues related to benthic resources, and affect on feeding habitats and occurrence of fishes along the beaches.

A final annual report must be submitted to the Corps within 30 working days after the date that the Corps provides comments on the draft to the Contractor.

5.0 References

Agresti, A. 1990. Categorical Data Analysis. John Wiley & Sons. New York.

Bogstad, B., M. Pennington, and J. H. Vølstad. 1995. Cost-efficient survey designs for estimating the food consumption by fish. Fisheries Research 23: 37-46.

Cytel Software Corporation. 2002. Proc-StatXact 5 for SAS Users. User Manual.

Gilbert, R. O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold. New York.

Green, R. H. 1979. Sampling Design and Statistical Methods for Environmental Biologists. John Wiley & Sons. New York.

Lehmann, E.L. 1975. Nonparametrics: Statistical Methods Based on Ranks. Holden-Day. San Francisco.

MMS 1998. Preliminary Assessment of Potential Sand Resources Areas Offshore of Nags Head, Kitty Hawk, and Kill Devil Hills, North Carolina. Prepared by Charles Hoffman, North Carolina Geological Survey, for Mineral Management Service, Herndon, VA.

Osenberg, C. W., R. J. Smith, S. J. Holbrook, K. E. Abu-Saba, and R. Flegal. 1994. Detection of environmental impact: natural variability, effect size, and power analysis. Ecological Application 4: 16-30.

Pennington, M. and J. H. Vølstad. 1994a. The effect of intra-haul correlation and variable density on estimates of population characteristics from trawl surveys. Biometrics 50: 725-732.

Pennington, M. and J. H. Vølstad. 1994b. Local homogeneity of marine populations and its implications for the design of sampling surveys. Invited paper for the Biometrics Society Conference on Sampling Issues in Ecology, Cleveland, April 1994.

Pollock, K.H., C.M. Jones, and T.L. Brown. Angler Survey Methods and Their Applications in Fisheries Management. American Fisheries Society, Special publication 25.

Scmitt, R.J. and C.W. Osenberg. 1996. Detecting Ecological Impacts. Concepts and Applications in Coastal Habitats. Academic Press. San Diego.

Shah, B. V., B. G. Barnwell, and G. S. Bieler. 1997. SUDAAN user’s Manual, Release 7.5. Research Triangle Park, NC: Research Triangle Institute.

Stewart Oaten, A., W. W. Murdoch, and K. R. Parker. 1986. Environmental impact assessment: “pseudoreplication in time? Ecology 67: 929-940.

Underwood, A. J.1991. Beyond BACI: experimental designs for detecting human environmental impact on temporal variations in natural populations. Australian Journal of Marine and Freshwater Research 42: 569-587.

Underwood, A. J. 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecological Applications 4: 3-15.

Underwood, A. J. 1997. Experiments in Ecology. Their logical design and interpretation using analyses of variance. Cambridge University Press.

Versar 2002. Effects of dredged material beach disposal on surf zone and nearshore fish and benthic resources on Bald Head Island, Caswell Beach, Oak Island, and Holden Beach, North Carolina: interim study findings. Prepared for the USACE, Wilmington District by CZR, Inc. by Versar, Inc. Columbia, Maryland.

Versar 2003. Year 2 recovery from impacts of beach nourishment on surf zone and nearshore fish and benthic resources on Bald Head Island, Caswell Beach, Oak Island, and Holden Beach, North Carolina: final study findings. Prepared for the USACE, Wilmington District by CZR, Inc. by Versar, Inc. Columbia, Maryland.

CZR 2003. Waterbird and shorebird use of beaches in Brunswick County, year 2. Prepared for the USACE, Wilmington District by CZR, Inc., Wilmington, North Carolina.

CESAW-TS-P 19 November 2004

DARE COUNTY BEACHES, NORTH CAROLINA (BODIE ISLAND)
COMMENTS AND RESPONSES TO ADDENDUM

1. **BACKGROUND**. The Report of the Chief of Engineers for the Dare County Beaches, North Carolina (Bodie Island Portion) Project, dated December 2000, included three conditions that required actions to be taken by USAED, Wilmington, during the pre-construction engineering and design (PED) phase of the project:

a. **Condition 1**. Undertake studies to confirm, or support revision of, the erosion damage relationships used in the project economics analysis.

b. **Condition 2**. Ensure that public access to all segments of the 14.2-mile-long project is consistent with law and regulation prior to initial construction and each nourishment.

c. **Condition 3**. Continue to coordinate with environmental resource agencies and environmental protection advocacy groups during the PED phase of the project to address their concerns and conduct studies or other activities as necessary.

CESAD-CM-P memorandum, 29 December 2003, subject: HQUSACE Policy Compliance Assessment—Responses to Chief of Engineers Report, Dare County Beaches (Bodie Island Portion), North Carolina, Final Feasibility Report and EIS transmitted the Addendum to the final feasibility report. An Addendum Supplement, dated June 2004, and transmitted via electronic mail on 23 June 2004, provided additional information. The Addendum (October 2003) addresses all three of the conditions cited above. The Addendum Supplement (June 2004) provides additional information in support of the erosion-damage functions and related assumptions.

2. **REVIEW SUMMARY**. In regard to the first condition cited, the October 2003 Addendum to the final feasibility report presents new “less aggressive” erosion damage functions for application to selected properties. The erosion damage functions are “less aggressive” in that they predict much less damage associated with a given amount of erosion through the footprint of pile-founded structures. For the limited cases where less aggressive erosion-damage functions have been applied, the district models predict significantly less storm damage and damages prevented compared to that predicted by erosion-damage functions applied in the feasibility study. The less aggressive erosion-damage functions were applied to about 15 percent of the total structure inventory. The original assumptions and erosion-damage functions

employed for about 85 percent of the total structure inventory remains unchanged from those presented in the 2000 feasibility report. In regard to condition 2, the addendum indicates that the non-Federal sponsor's public access plan is currently under development and will be completed prior to signing the initial Project Cooperation Agreement. In regard to condition 3, the addendum documents that considerable effort has been expended to continue coordination with environmental resource agencies and environmental protection advocacy groups. The addendum notes that while much progress has been made, the stated non-favorable positions of these groups have not changed.

3. **ADDENDUM SUPPLEMENT**. Paragraph 4, page 6 of the Addendum Supplement (June 2004) states the following: *"In support of the use of the District's aggressive erosion-damage curve, we offer the fact that many of these oceanfront homes built on deeply embedded pilings are condemned following a storm event because of washed out septic systems or other utilities. Until they are repaired to the satisfaction of local inspectors, future habitation will be denied, and these homes are essentially worthless though they may still be standing."* The review team believes that there may be a significant difference between the cost of sand replacement, major foundation repair and rehabilitation, and replacement of a septic system or other utilities and 100-percent of the depreciated replacement cost of the total structure and its contents. Clearly, modeling that assumes that it is appropriate to claim 100-percent damage for the situation described above seems unfounded.

The following is an excerpt from the letter from Spencer Rogers regarding structures located in the study area (after page 10 of the Addendum Supplement).

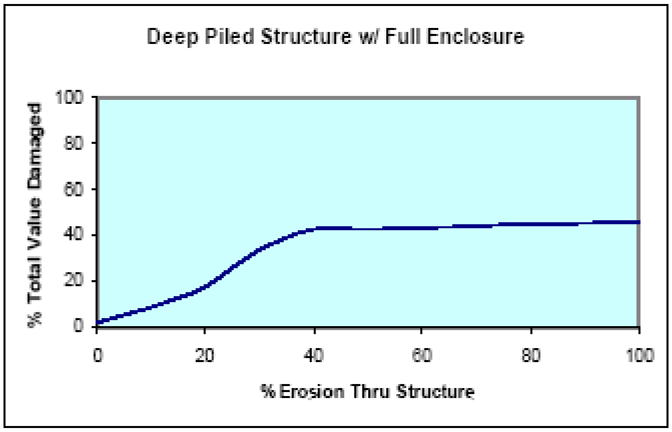
> *"…As progressive erosion has gradually undermined older buildings, property owners have modified the original shallow piling foundations. As each row has been undermined during small storms, the pilings have been replaced or bolted to new, deeper pilings (sistered). Any pilings not exposed by prior erosion cannot be easily accessed for improvement."*

Mr. Rogers' statements suggest that there are existing structures located in the project area that have been subjected to storms were erosion has been sufficient to remove significant amounts of sand from "shallow" (8-foot embedded) pilings. Apparently these structures have survived and have had substantial foundation repairs effected (old shallow pilings have been "sistered"). The costs of such repairs were, no doubt, substantial. However, it is not reasonable to assume that those repair costs approximated 100-percent of the depreciated replacement cost of the structure and it's contents. It appears that using the district's aggressive erosion-damage curves and modeling assumptions (6 inches of erosion at the structure's midpoint where there are 8-foot-deep embedded piles), such structures and their contents would have been declared destroyed—that is, a 100-percent loss. In other words, using the district's assumptions, the "pile sistering" evident in the project area could never occur. Clearly, this is not the case (see below, page 24 of the Addendum Supplement). Model results should closely approximate actual experience. Thus, the modeling assumptions employed in the current study do not appear to reflect reality as documented by filed surveys.

Eventually erosion will reach the bottom of the extended pilings.

Paragraph 8, page 8 of the Addendum Supplement (June 2004) states the following: *"…our model allows for rebuilding structures lost in storms provided setback restrictions are met. Only after long-term erosion has claimed more distance on the oceanfront lot than the building requires to be put back, does our program cease to reinstate the same property."* The economic evaluation assumed that long-term erosion averaged about two (2) feet per year. Thus, typically, it may take more than 30 years of a 50-year life-cycle simulation for long-term erosion to advance 60 feet landward. During this 30-year period the district's model can assume that a structure and it's contents are destroyed and replaced multiple times. Assuming that a structure is "essentially worthless" as described previously, and is repeatedly replaced only to be "totaled" again, and again in subsequent model iteration cycles most probably does not approximate reality.

The district's modeling assumptions predict significant storm-induced erosion damages to even some structures founded on deeply embedded (16-feet embedded depth) piles as is indicated on page 35 of the Addendum Supplement.



Often, the structure in question has a large enclosure on the ground floor. This curve was used for a 1-story house on pilings with a full finished enclosure. The enclosure is given a value of 40% of the entire structure and the rest of the structure is given the remaining value of 60%. These percentages were then used to weight the damage curves for the home and the enclosure, deriving a composite damage curve.

The erosion-damage function above indicates that the district's models assumes that 40-percent of the total value of a structure and contents occurs when six inches of storm-induced erosion reaches the midpoint of the structure. The assumption here is that even though the first floor of the structure is elevated above the 100-year flood level in compliance with local and Federal regulations, 40-percent of the value of the structure and it's contents is contained in an enclosure built below the 100-year flood elevation. The review team considers this to be an overly aggressive assumption in several respects. First, given the apparent intent of Section 308 of WRDA 1990, it is not clear that it is appropriate to claim benefits for preventing damages sustained to shorefront enclosures constructed below the 100-year flood elevation. Such enclosures and contents are not insurable under the Federal Flood Insurance Program regulations. Secondly, constructing such enclosures clearly circumvents the intent of local and National floodplain regulations designed to discourage unwise shorefront development. And, finally, assuming that homeowners intentionally place 40-percent of the total value of a structure and its contents at uninsurable risk may violate our requirement that Corps' economic evaluations conform to principles of economic rationality.

The compounding effect of aggressive erosion damage curves, damage assumptions that do not reflect observed practice, and unlikely replacement assumptions have been and remain the essence of the concerns expressed by the HQ review team and the OASA(CW).

Subject: HQUSACE Policy Compliance Review Comments—Addendum (December 2003) and Addendum Supplement (June 2004) to the Dare County Beaches, North Carolina (Bodie Island) Final Feasibility Report and Environmental Impact Statement (2000)

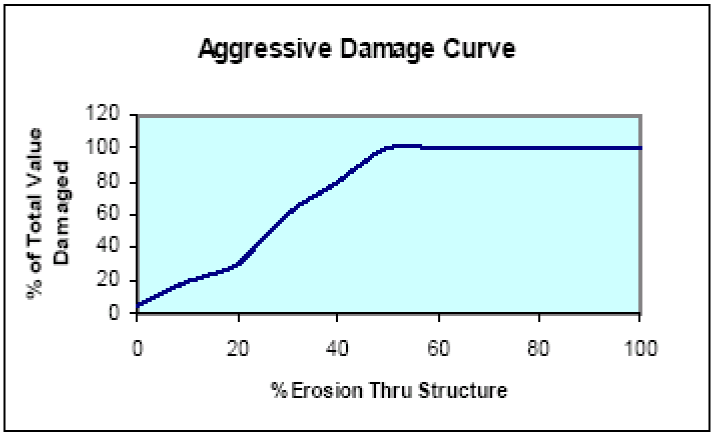
Response: *We believe that damages sustained by newer structures built in conformance with local building codes, FEMA requirement, and CAMA regulations should be considered legitimate damages and the prevention of these damages should be considered NED benefits. As a result of recent hurricanes, property owners face higher insurance premiums, higher deductibles, and items exempt from insurance coverage. There have been several storms in the area causing significant damages. These costs are true and known, so we don't believe conditions exist for economic irrationality. More likely, the benefits to the property owner and any guests or rental clients outweigh the costs of expected damages.*

4. **SHALLOW PILE-FOUNDED STRUCTURES LOCATED ON HIGH DUNES**. The HQ review team concurs that the most aggressive modeling assumptions used in the study may be most applicable to the "high dune" situation depicted below. However, it is not clear that the most aggressive erosion-damage curves and modeling assumption were only applied to the "high-dune, shallow pile" situations.

This photo demonstrates why Spencer Rogers predicts one set of responses for a high dune situation and another set of curves for a low dune situation. Most of these homes are build on 8-foot embedded pilings. When erosion at the toe

The October 2003 Addendum notes that new "less aggressive" erosion-damage functions were applied to reanalysis of 95 structures in the North Reach. The "less aggressive" curves were applied to 410 structures in the South Reach. Thus, it appears that assumptions and erosion-damage function applied to about 3,200 of the 3,700 structures evaluated remained unchanged from the original analysis shown in the final feasibility report. Damages for over 86 percent of the structures are derived by use of the original ("aggressive") erosion damage functions (see below).

Subject: HQUSACE Policy Compliance Review Comments—Addendum (December 2003) and Addendum Supplement (June 2004) to the Dare County Beaches, North Carolina (Bodie Island) Final Feasibility Report and Environmental Impact Statement (2000)



This is the erosion-damage curve that the Wilmington District used most often in the Dare County analysis. It represents an average response of pile supported structures to storm generated erosion taking into consideration the multitude of variables discussed herein and the lack of any reliable data. Many of the project reviewers have questioned this curve with the general consensus being that it is too aggressive. In the January 2003 reanalysis, structures that were found to be on deeply embedded pilings and/or located on a flat profiled section of shoreline, were reassigned a less aggressive damage curve. The January 2003 reanalysis led to changing the erosion-damage relationship on 410 structures or 19 percent of the total structures in the South Project area. The District maintains that this curve is applicable for some piled structures with no enclosures, but only those on 8-foot embedded pilings located atop high dunes.

In contradiction to the last statement in the caption above, page 9 of the October 2003 Addendum states the following: *"…Residential structures along the second row of development were also assigned an erosion-damage curve specific to their building characteristics, which often include shorter pilings. In this case, the structures were often assigned a more aggressive erosion-damage curve like curve 4 shown below."* The referenced "curve 4" is the same "aggressive damage curve" shown above. The district and division should certify that the 3,200 structures to which the "aggressive damage curve" was applied are structures with 8-foot-deep embedded piles located on high dunes as depicted above. If this is not the case, it appears that the *$35.4 million in expected annual benefits* claimed for the 14.1 mile-long project area is greatly overstated. To achieve *$35.4 million in expected annual benefits* it appears that several storms causing many billions of dollars in single event damage would have to occur during the period of evaluation. Such storms, while possible, have never been experienced.

Response: *The 3,200 structures were examined individually in the field and determined to warrant an aggressive damage curve. Our experience, confirmed by Spencer Rogers, is that these structures are severely damaged by storms.*

From Appendix H of the Feasibility Report, expected annual damages in the study area are $37.86 million dollars and expected HSDR benefits of the NED plan are $31.55 million dollars. The $35.4 million includes recreation and benefits during construction. The present worth of expected annual damages would be about $550 million. Since storms have historically occurred every few years, average damages from storms would be less than $100 million rather than in the billions. But rare events could certainly cause damages above a billion dollars.

5. **PROPOSED STRUCTURE REPLACEMENT ASSUMPTIONS**. Paragraph 8, page 8 of the Addendum Supplement states the following: "*The District stands by its replacement assumption, which we believe is rather conservative since typically each destroyed structure is rapidly replaced with a more valuable building than the one lost. The reality is that as each structure is lost to long-term erosion, it is rapidly replaced with a more valuable building than the one lost. To show the impact of incorporating this assumption, the District included a run in this sensitivity set to show what happens as structures are taken out of the database due to long-term erosion, are they are replaced by the average structure being built today. In the case of Dare County, the replacement structure value averages more than $500,000. Again, this assumption was not used in the Dare County Feasibility Study, but we plan to incorporate it into our future beach analyses because the District feels this scenario most closely represents reality.*"

The impact that the proposed structure replacement assumption would have on the Dare County project evaluation is indicated in the following tabulation. Given this "new" most probable future-without-project condition the district's models predict that theoretical damages (without-project) and theoretical damages prevented (with-project) more than double compared to simply not rebuilding structures that sustain substantial storm damage. The tabulation shows the discounted present values (PV) of benefits and costs for various scenarios where structures that sustain greater than 50-percent damage are rebuilt and continue to be damaged over the period of economic evaluation. The present values are discounted at 6.625 percent--the discount rate used in the Dare County feasibility study. The "Improved" replacement scenario represents that situation where an older structure is replaced with a more expensive, more damage resistant one.

Project Reach	**Scenario**	**PV Benefits**	**PV Costs**
South	1. NED	$342,927,515	$141,645,449
	2. No Replacement @ 50% damage	178,549,784	141,645,449
	3. Improved 1 Replacement	360,929605	141,645,449
North	1. NED	$115,600,000	$99,100,000
	2. No Replacement @ 50% damage	70,067,142	99,100,000
	3. 1 Replacement @ 50% damage	87,873,880	99,100,000
	4. 2 Replacements @ 50% damage	99,107,708	99,100,000
	5. Improved 1 Replacement	143,606,288	99,100,000

Note that damages (without project) and damages prevented (with project) more than double with a one-time structure replacement (*Improved 1 Replacement*) compared to the no replacement (*No Replacement @ 50% damage*) scenarios. This outcome has troubling implications in regard to coastal management regulations that allow rebuilding of substantially damaged structures. The district models assume that structures will be rebuilt as long as long-term erosion (as opposed to short-term, storm-induced erosion) has not decreased the size of a lot to a point where minimum setback requirements cannot be achieved. Apparently, this assumption conforms to the provisions of the North Carolina Coastal Area Management Act (NC CAMA). However, the scenarios cited above suggest local and Federal floodplain management regulations ostensibly designed to limit future hurricane and storm damages are ineffective as currently implemented.

Response: *The beaches of Dare County are important economic resources that help drive employment and income in the State and Region. While building standards are an important component of CAMA regulations, they are much more effective if a berm and dune exists along the front beach. Looking at pictures of exposed houses and damages from recent hurricanes in Florida and Alabama, storm resistant structures are unlikely to solve the problem alone.*

6. **IMPORTANCE OF REASONABLE EROSION DAMAGE FUNCTIONS**. In previous responses to review concerns CESAW indicated that the storm damage model is mostly insensitive to the fact that the first floor of most structures may be elevated above the 100-year flood level. Neither wave damage nor inundation damage is significant in the storm damage analyses. More than 80 percent of the storm damages claimed is related to storm-induced erosion:

"Wave damages are generally taken as 100 percent if the first habitable floor of the structure can be impacted by a wave height of at least 3 feet. In order for this to occur, a water depth of 4 feet must be present at the base of the structure in order to support this wave height and the full

height of the wave must be able to impact the side of the building. In most cases, where buildings are supported on piles, the first habitable floor is elevated above the 100-year flood level. Due to the severity of this condition, very few of the model predicted damages to the coastal structures result from the direct impact of waves.

In a similar manner, damages due to inundation are determined by the combined height of the storm still water level and a superimposed wave height. Based on the elevation of this combined height and the elevation of the structures first floor, the amount of inundation damage is determined from a standard set of inundation damage curves. Unless the predicted amount of storm induced erosion is sufficient to completely erode the ocean front dune, the residual height of the seaward edge of the beach is generally sufficient to limit the height of the wave that could be transmitted across the beach face without breaking. Accordingly, since the conditions necessary to cause a prediction of significant inundation-related damages is rather severe, damages due to the inundation (combined storm still water level and wave height) rarely controls."

"Damages due to storm-induced erosion are the major damages that are generally computed by the economic model. . . . For buildings along the coast of North Carolina, most of which are supported on piles, once the 0.5 foot point of erosion reaches the mid-point of the building, all protective measures fronting the building have been removed exposing the building to the full brunt of the storm including direct wave impact and inundation. While the vertical scour around the ocean front piles may not cause the building to collapse, the open exposure caused by the storm induced erosion and lowering of the beach fronting the building is judged to be sufficient to result in complete loss of the economic value of the building even though the building may be left standing…."

The Addendum notes that different "less aggressive" erosion damage curves (Curves 1, 2 and 3 shown on page 8 of the addendum) were applied to some structures. For the limited cases where less aggressive erosion-damage function have been applied, the district models predict significantly less storm damage and damages prevented compared to that predicted by erosion-damage functions applied in the feasibility study. Page 10 of the Addendum shows that benefits for the South Reach are reduced by about 20.3 percent based on use of the "new" erosion-damage curves. However, use of the "new" erosion-damage curves resulted in total benefits for the North Reach being reduced by only 0.55 percent. Text on page 11 notes that the new erosion-damage functions were applied to reanalysis of only 95 structures in the North Reach. The "less aggressive" curves were applied to 410 structures in the South Reach. Thus, it appears that assumptions and erosion-damage functions applied to about 3,200 of the 3,700 structures evaluated remained unchanged from the original evaluation shown in the final feasibility report. Damages for over 86 percent of the structures are derived by use of the original ("aggressive") erosion damage functions.

Prior informal polling of Corps coastal districts indicated that the erosion-damage function used for most of the pile-founded structures in the current study is the most "aggressive" employed by any Corps district. Other districts (CENAP, CESAC, CESAM) generally cited post-storm damage survey data as the basis for their erosion-damage relationships. Generally, for pile-founded structures, CENAP assumes 100 percent damage when the leading edge of storm recession is completely (100 percent) through the breadth of the structure. Generally, CESAM assumes 30 percent damage when the leading edge of storm recession encroaches 100 percent through the breadth of a pile-founded frame structure. CESAM assumes 60 percent damage when recession extends 50 percent through a masonry structure founded on piles, and 80 percent damage when recession extends 100 percent through such structures. For the Foley Beach study, CESAC assumed 7 percent damage for 100 percent storm recession through pile-founded structures when the area under the structure was not enclosed. The Foley Beach study assumed 25 percent damage when the area under the structure was enclosed.

The significant variance in damages attributed to storm recession under pile-founded structures by CESAW compared to other Corps coastal districts remains cause for concern. This is especially so given that CESAW concedes that the erosion-damage curve in question is based solely on professional judgment. While based on the best judgment of SAW coastal engineers, the erosion-damage functions cannot be verified as appropriate. CESAD/CESAW, in cooperation with the Corps hurricane and storm damage reduction Planning Center of Expertise, should seek the views of nationally recognized coastal engineering experts in assessing the validity of the selected erosion-damages functions. A request for an external technical review by the National Academies may be appropriate in this regard.

Response: *As discussed at the Strategic Planning Meeting, the District ran a series of sensitivity analyses of the erosion damage curves. This information was reviewed by the Philadelphia District in their role as the HSDR Center of Expertise. This analysis is presented in the Addendum and the review is attachment 3.*

7. **SIGNIFICANT DAMAGE THRESHOLD INDICATOR**. The Addendum (October 2003) states that use of the point where the model predicts that 0.5-feet of erosion occurs as an indicator of the landward extent of storm-induced erosion has been "criticized." This is not correct. As is noted in the addendum, the 0.5-foot indicator has been widely used in Corps hurricane and shore protection studies. *Primarily, the review team questioned the assumption that the landward extent of storm-induced erosion effects need only progress to the midpoint of a pile-founded structure to cause 100-percent loss of that structure and it's contents*. The erosion-damage functions represent the single most important critical assumption in the project evaluation. Consequently, the purpose and significance of the damage indicator sensitivity test presented in the October 2003 Addendum is not apparent. The value of the presentation on storm profiles on pages 22 and 23 would be enhanced if the ocean front and second line structures were shown in comparison and one could picture the pile depths relative to the erosion

losses. Beyond the distance of 110 feet or so, the profiles seem to be accreting during a storm. Are the houses affected built directly on the dune?

The April 2002 paper by Spencer Rogers states: *"Significant damage to deeper imbedded pilings is likely to begin when the erosion depth exceeds 4 feet, half the embedment depth of 8 feet."* It appears that exposure of one-half of the embedded pile depth is a more reasonable indicator of the potential for significant structure damage than the 6-inch indicator used for the Dare county feasibility study. The HQ review team believes that it is notable that recent hurricane and storm damage studies from the Wilmington district propose to use the point on the beach profile where 4-feet of erosion occurs as the threshold indicator of where significant erosion damage occurs. We believe that it may not be reasonable to assume 100-percent loss of a structure and contents without at least one-half of the embedded pile depth being exposed by erosion.

Response: *The use of other erosion indicators other than the 0.5-foot indicator began with the Rogers April 2002 paper. We prepared a sensitivity analysis varying the distance of erosion from various storms to see the impact on damages and benefits. Doing a sensitivity analysis of the erosion distance is similar to using other indicators that would be further seaward and create less damages and benefits.*

8. **PUBLIC ACCESS**. The addendum indicates that the sponsor is developing the plan for the required public access including parking. It further states that the PCA will outline the details for the public access requirements. Paragraph 6.h.(3) of ER 1165-2-130 states that the items of local cooperation in the recommendations should specify the necessary access requirements and public use throughout the project life or the project cost-sharing should be modified to reflect private use for those areas where public access is not provided. More detailed public access language is needed than the standard PCA language, so that it is clear what access points/facilities are required prior to construction in order to satisfy the conditions stipulated in the Chief of Engineers' Report and to assure that the project is cost shared appropriately. Otherwise, there is potential to lose track of the requirements. The requirement cited in the report of the Chief of Engineers will be satisfied with submission of the non-Federal sponsor's documentation.

Response: *A detail GIS map of the existing and proposed access points is shown in attachment 4. We have also attached a letter from Dare County, the non-Federal sponsor, committing to meet the parking and access requirement of the Corps of Engineers. The PCA will be written to satisfy the requirements in the Chief's Report.*

9. **CONTINUED ENVIRONMENTAL COORDINATION**. The addendum summarizes results of various stakeholder meetings that have been held since March 2001 to address economic analysis, GRANDUC modeling, cumulative impact analyses, monitoring requirements, and real estate. The addendum notes that a comprehensive pre-construction and

post construction monitoring plan is under development by cooperating agencies including the U.S. Fish and Wildlife Service, National Marine Fisheries Service, North Carolina Division of Marine Fisheries, and the North Carolina Division of Coastal Management. The comprehensive monitoring plan is to address recovery of benthic food sources in the borrow area and help develop a better data base to assess significant impacts on habitat, near shore fisheries, shorebirds, and/or indicator species. The addendum notes that while much progress has been made, the stated positions (negative) of environmental resource agencies and environmental protection advocacy groups have not changed. It is anticipated that the project will proceed as planned. Hard data generated by the comprehensive monitoring plan may be useful in clarifying the extent and significance of project-driven environmental impacts.

Response: *The Addendum addresses the environmental coordination and results. The monitoring plan is included as attachment 5.*

10. **CLARIFYING INFORMATION**. Page 4 indicates that the Addendum is intended to be an independent self-contained document. Addition of clarifying information noted in the following could be helpful in achieving this goal.

Response: *We have revised the referenced sentence to indicate that we expect the Addendum to include complete data on the analyses performed, but it is not to repeat information from the Feasibility Report. Some information is still only available in the Feasibility Report.*

a. <u>Percentage for Enclosure Structure</u>. The evaluation assumes that full enclosures constitute 40 percent of the value of the entire structure and its contents. Is this percentage based on actual damage survey data? Some sensitivity in regard to the value might be helpful.

Response: *This percentage is based on field data collection and discussions with local realtors.*

b. <u>AAD per Structure</u>. It would be helpful to include a tabulation of AAD for beachfront structures, the number of structures and their average value. This would allow for comparison of the AAD per structure versus structure value.

Response: *There are 4,991 structures in the study area with an average value of $119,000. The average annual damages per structure are about $7,600 including contents, land loss and damages to roads and utilities. This amounts to about 6 percent of the value of the structure. We do not have a separate breakout for oceanfront structures, but only about the first 3 rows of houses were inventoried. Any damages prevented beyond the first 3 rows would not be captured in our models.*

c. <u>Failure Mechanism</u>. The addendum should reference engineering analyses that support the conclusion that the failure mechanism is reasonable for the various assumed pile lengths. Pile-founded structures can be pretty resistant to wave action if they are substantial enough. For instance, some of the beachfront structures in Delaware were constructed right on the beach just ahead of a moratorium on development. After construction, storm events removed enough material that a person could walk under the closed garage door of some houses. The primary damages were that the stairs had to be extended 6-8 feet to reach the beach. Also the street pavement and driveways along with some utilities had to be repaired.

Response: *While we believe our erosion damage curves and structure failure points are reasonable, we have depended mainly on post-storm assessments and the work of Spencer Rogers to validate them. It would be possible to construct buildings in front of the protective dunes using extremely well-engineered foundations that could stand up to certain storms. The photographic evidence from Gulf Shores and Orange Beach, Alabama after Hurricane Ivan, shows that even new construction sustains severe damage when adequate berm and dune protection is not provided.*

d. Project Limits. Table 1 on page 12 shows HSDR benefits (AAB) of $5,997,100 for the North Reach and $16,932,600 for the South Reach. The total project length for both reaches is reported as 14.2 miles, or roughly 75,000 feet. It isn't clear from the addendum data what 1000-foot reaches correspond to the actual north and south project segments. The text indicates that reaches with negative net benefits were included in the project limits where there was insufficient distance for a 3000-foot transition. Annotating the table information would help to support the designation of the NED plan, based on the revised economic data. Looking at the data in the table one cannot verify that the information supports the project limits recommended. Also it cannot be verified that the transition zone benefits have been accounted for in the total AAB.

Response: *Complete information on the recommended plan and its components is presented in the Feasibility Report. Reaches shown in Table 1 are of varied length, and cannot easily be added to equal the project length. For example, the 3,000-foot transition zone at the ends of each project may be divided into 4 to 7 reaches, depending on the shape of the shoreline. Each project ends at a reach that increases net benefits and includes a 3,000-foot transition zone. Transition zone benefits are included in the totals.*